RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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Comparative Radiotherapeutic Results in Carcinoma of the Endometrium as Modified by Prior Surgery and Post-Irradiation Hysterosalpingo-Oophorectomy[1]

HOWARD B. HUNT, M.D.

THE INCIDENCE of endometrial carcinoma involving the uterine corpus is gradually approaching that of squamous-cell carcinoma of the cervix, due primarily to aging of the population. The ratio of cervical to endometrial cancer in white married women between the ages of thirty-five and thirty-nine is reported (11) to be 8:1; at sixty-five years, 1.5:1. In material from the University of Nebraska clinics and our private practice in Omaha, the incidence of endometrial carcinoma was found to reach a peak at sixty years, as compared with forty-eight years for cervical carcinoma. The ratio of cervical to endometrial cancer in the clinics was 3.5:1 in 1936–40, while the present ratio is 1.7:1. In 1953 Tweeddale (36) reported endometrial carcinoma to be 1.5 times as common as carcinoma of the cervix at Lincoln, Nebraska.

In Nebraska, total deaths from uterine cancer declined from 11.5 per 100,000 total population in 1944–48 to 8.4 in 1949–53. Massachusetts showed a reduction in deaths due to this cause from 18 per 100,000 total population in 1932–34 to 10.5 in 1950–52. This decline apparently results from improved control of both cervical and endometrial carcinoma, as well as from the somewhat better general survival rate, with relatively more cases of endometrial cancer. Connecticut (14) shows an improvement in five-year survival rates for cervical cancer from 30 per cent in 1935–40 to 50 per cent in 1947–50; for corpus cancer, the increase was from 44 to 61 per cent during this same period. Our five-year survival rate for carcinoma of the cervix advanced from 20.5 per cent in 1931–36 to 48 per cent for all combined clinic and private cases seen during 1937–47, and to 57 per cent for 107 private cases, unmodified by prior treatment, during the latter period (17). For endometrial carcinoma treated during 1930–36 (24) our five-year survival rate was only 35 per cent, while for the 1937–49 period it was 60.9 per cent of all cases seen; 65.3 per cent of all cases (clinic and private) unmodified by prior therapy, and 78 per cent for unmodified private cases alone. In private cases, better survival rates may be anticipated, primarily because the patients are younger, there is less intercurrent disease, the lesions are earlier, and more integrated control of the therapeutic procedures in unmodified cases is possible. Improvement in our overall five-year survival rate may be attributed to relatively more favorable cases, better radiotherapeutic

[1] Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

methods, more individualization of management, and, in operable cases, increased utilization of hysterosalpingo-oophorectomy following radiotherapy.

Carcinoma of the endometrium exhibits some predilection for a particular constitutional type (27), characterized possibly by anterior pituitary dominance, according to Way (38). Kottmeier (20), in an analysis of 1,239 cases of corpus carcinoma, found that 35.9 per cent of the patients had never been pregnant; 37.7 per cent had associated uterine fibroids; 19.3 per cent showed marked arteriosclerosis, often with myocardial insufficiency; 11.8 per cent had hypertension above 200 mm. Hg; 30 per cent weighed over 175 pounds; 6 per cent had diabetes. Way reported diabetes to be twenty-eight times as common in patients with corpus carcinoma as in control groups. As a result of the high incidence of hypertension, cardiovascular disease, and diabetes, Kottmeier found that 9.4 per cent of the patients with corpus carcinoma died of intercurrent disease within five years and 21.7 per cent died of diseases other than uterine cancer within ten years. This high death rate from intercurrent disease significantly limits the potential for absolute five-year survivals to less than 90 per cent in endometrial carcinoma. The menopause occurred past fifty years of age in over half the cases seen by Way, and uterine polyps were definitely more common than in controls. Gusberg (15) considers adenomatous hyperplasia a forerunner of endometrial carcinoma in 10 to 20 per cent of cases. Taylor (35) and Speert (34) report the occurrence of carcinoma of the breast in about 2.4 per cent of patients with corpus carcinoma. Cancer of the ovary, primary or metastatic, was present in 6 per cent of Kottmeier's cases. Carcinoma of the uterine corpus, breast, and ovary thus appear to have some common endocrine denominator, all being relatively more frequent in infertile and unmarried women. Granulosa- and thecal-cell tumors of the ovary were reported to be associated with endometrial carcinoma in 14.8 per cent of cases reviewed by Speert, but Kottmeier suggests that atypical hyperplasia has probably been misinterpreted as endometrial carcinoma in some of these cases.

Various methods for staging endometrial carcinoma have been proposed (12, 18, 35) but only those based on clinical examination are applicable in radiotherapy. Proper evaluation requires a bimanual rectovaginal examination, general physical examination, and history. We follow the staging set forth in the Stockholm League of Nations report on carcinoma of the uterus (3, 16, 19, 20). Stage 0, which includes cases of questionable cancer showing irregular atypical endometrial hyperplasia, is excluded from the present study, though such hyperplasia becomes significant after the menopause, particularly if it is adenomatous. Stage I refers to definite carcinoma clinically confined to the uterus. Stage II includes endometrial carcinoma which has spread beyond the uterus, as based on observation of an irregular extrauterine mass, obvious invasion of surrounding tissue, or evident metastases. Staging based entirely on clinical findings is admittedly approximate and subject to some variability in individual interpretation.

Carcinoma of the corpus should, if possible, be differentiated clinically from carcinoma involving the corpus and endocervix, as recommended by Heyman (16) and Kottmeier (19). Such differentiation is based on rectovaginal examination, fractional curettage of the cervix and corpus separately, and instrumental location of the lesion within the uterus. The ratio of corporal to endocervical lesions is 5 to 1. Although both lesions are endometrial cancer and both occur in the older age group, they differ in clinical course, prognosis, and indicated therapeutic procedure. Endometrial carcinoma involving the endocervix spreads early to the paracervical lymphatics and pelvic nodes, with report of nodal metastases in 25 per cent of operative specimens, whereas only 10 per cent of lesions confined to the

corpus show nodal involvement (18). The clinical course and indicated treatment for endocervical carcinoma parallel the course and indications for squamous-cell carcinoma of the cervix. If hysterectomy is performed for endocervical carcinoma, radical lymph node dissection may warrant consideration. Radiotherapeutic management requires more intensive irradiation of the vaginal vault, paracervical regions, and pelvic nodes. According to Kottmeier (20), the five-year survival rate for carcinoma of the corpus is 61.8 per cent as compared with 32.9 per cent for carcinoma involving both corpus and endocervix.

The preferred treatment for endometrial carcinoma is currently a controversial subject. Immediate hysterectomy without radiotherapy is advocated in all instances by McKelvey (25), Bastiaanse (4), and Speert (34). Radical hysterectomy with lymph node dissection has been recommended by Brunschwig (5). Hysterectomy followed by vaginal irradiation is favored by Dobbie (10). Initial radiotherapy immediately followed by hysterosalpingo-oophorectomy is the choice of Addington (1), while hysterectomy performed after a six- to twelve-week delay is advocated by Ward (37), Randall (30), Scheffey (31), Payne (29), Leucutia (22), Schmitz (32), Arneson (3), Miller (26), and Cosbie (7). Heyman (16) uses primary radiotherapy in all instances, limiting hysterectomy to operable cases in which radiotherapy has apparently failed to control the cancer; in his series, these cases comprised 16.3 per cent of the total. Primary radiotherapy with complete exclusion of hysterectomy in all cases seems to have no supporters at this time.

RADIOTHERAPEUTIC PROCEDURES IN ENDOMETRIAL CARCINOMA

The following methods of radiotherapy are used in the treatment of carcinoma of the endometrium: (*a*) primary radiotherapy alone, (*b*) irradiation followed by total hysterosalpingo-oophorectomy, (*c*) postoperative therapy following total or subtotal hysterectomy, (*d*) therapy to recurrent or metastatic cancer subsequent to hysterectomy or irradiation. Literature concerning the optimal management of endometrial carcinoma has been carefully reviewed and well summarized by Freed and Pendergrass (13). In our experience, the effectiveness of radiotherapy in carcinoma of the endometrium has been increased by the use of multiple intrauterine capsules rather than a single uterine tandem, by more adequate irradiation of the vaginal vault and tract especially in postoperative cases, by more effective use of external roentgen therapy, and by radiographic recording of radium placement and more precise measurement and calculation of dosage.

The most homogeneous and effective irradiation of cancer along the uterine wall is achieved by packing the cavity with multiple capsules, as introduced by Heyman (16). In his experience, the five-year survival rate increased from 45 per cent with a single tandem to 65 per cent following the use of multiple intrauterine capsules. Nolan (28) measured the dosimetric pattern about various intrauterine applications and found the multiple capsule pattern to be most effective. Arneson (2) found residual carcinoma in 77 per cent of uteri treated by tandem alone and in only 29 per cent of cases in which multiple capsules were used, with a corresponding increase in five-year survival rate from 54 to 79 per cent. The distribution and number of capsules will vary with the contour and size of the uterine cavity (Fig. 1). The cervical canal must be well dilated and the possibility of uterine perforation excluded before introduction of the individual capsules, each of which contains 5 to 10 mg. of radium or its equivalent in radiocobalt. Schmitz (32) has developed an expandable Y radium applicator which is quite adaptable to regular uteri, of average size, but less adequate for large uteri with irregular cavities.

It is of advantage to fractionate the total intrauterine dosage into two or more applications, spaced at intervals of one to

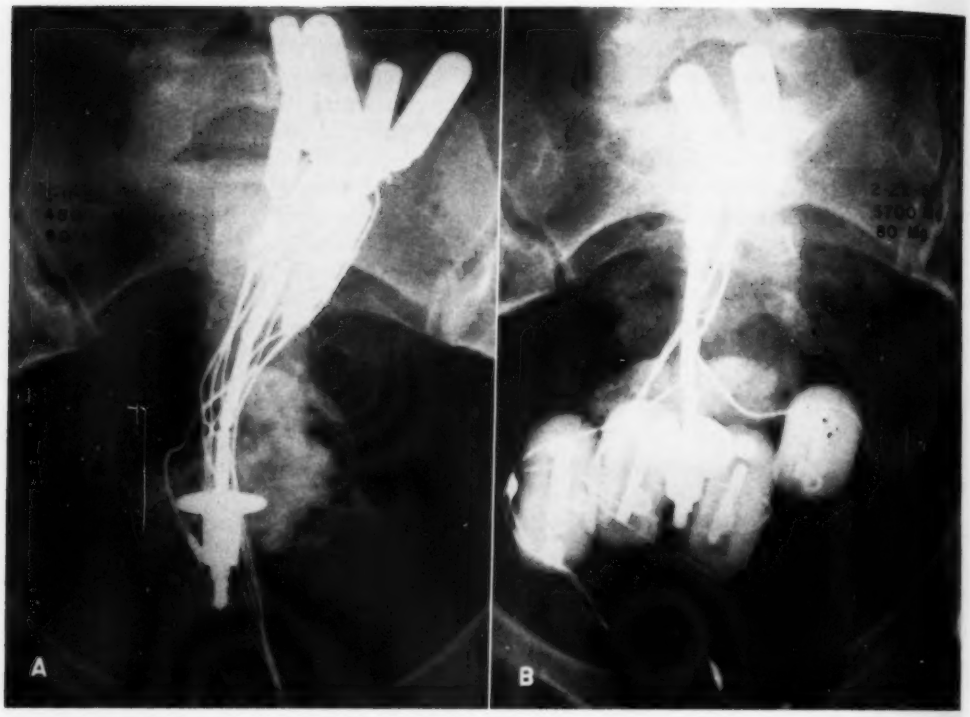

Fig. 1. Endometrial carcinoma of corpus uteri treated by external roentgen therapy and (A) radium in multiple intrauterine capsules and (B) vaginal colpostats; no histologic evidence of residual cancer was found at hysterectomy eight weeks later.

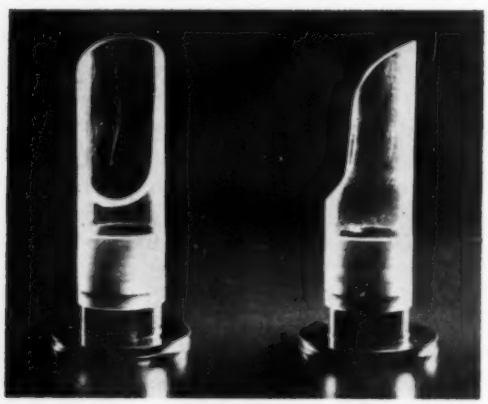

Fig. 2. Transvaginal cylinder obtusely beveled to permit roentgen irradiation of vaginal walls.

three weeks, although a single application may be sufficient if hysterectomy is assured, or in uteri under 6 to 8 cm. in length which are involved by a superficial or early carcinoma. Fractionation of dosage and reapplication of radium are particularly important in large uteri with bulky tumors, and mandatory when subsequent hysterosalpingo-oophorectomy is not assured. Progressive shrinkage of the cancer between applications permits more effective delivery of a higher dose to the peripheries of the lesion in successive doses. Furthermore, therapy thus administered is better tolerated, as a result of some relative recovery of normal tissues in the intervening period; the later application may be adjusted in position and dosage to compensate for prior placements and in accordance with the type and severity of the reactions. Placement of radium applicators should always be radiographically recorded in two planes. The radiographs afford data for calculation of dosage, reveal possible misplacement or extrusion of radium applicators, and provide a permanent record for reference.

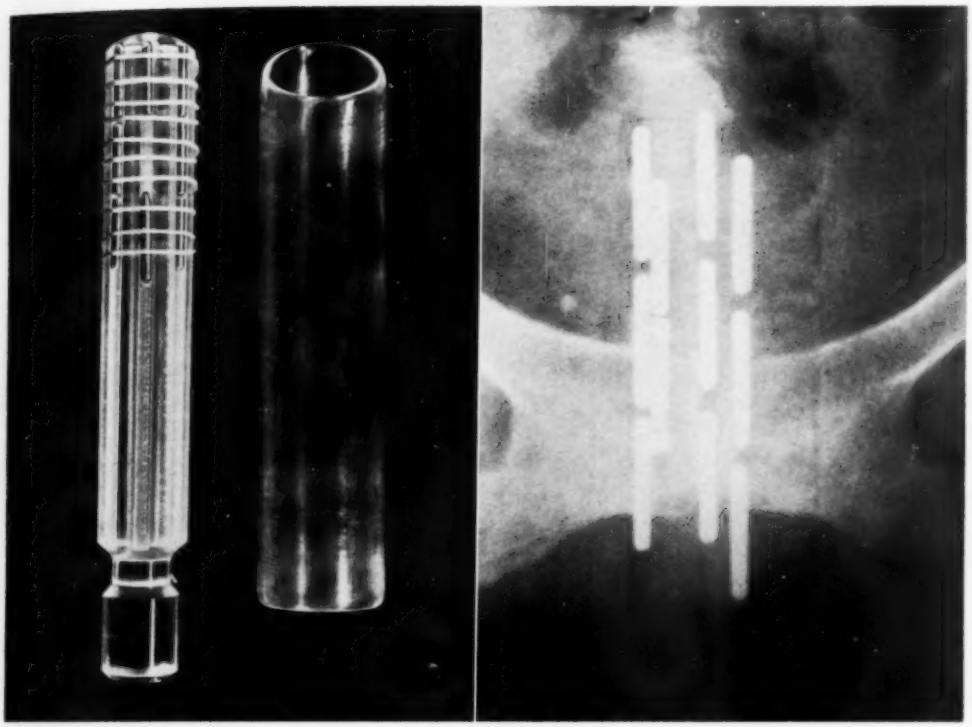

Fig. 3. Intravaginal applicator (in three sizes) consisting of cylindrical plastic sheath, solid plastic insert drilled in the center, grooved on the surface, and encircled by elastic bands permitting variable placement of radium capsules.

Adequate irradiation of the vaginal vault and walls is an integral part of the radiotherapeutic management of endometrial carcinoma. In postoperative treatment, vaginal irradiation is most essential. Ingersoll and Meigs (18), in a review of 213 surgical cases, encountered 9 instances of recurrence at the vaginal apex, 10 along the vaginal wall, and 3 about the urethra. Vaginal recurrence was thus found in about 10 per cent of their series of endometrial carcinomas following hysterectomy. Dobbie (10) observed vaginal recurrence in 7 of 66 patients treated by hysterectomy alone. The rate of recurrence (8 out of 80 cases) was equally high among patients receiving conventional external roentgen therapy. Vaginal recurrences were, however, nearly eliminated by irradiation of the vaginal mucosa to a dose of 5,000 r delivered by radium in a plastic piston applied three to four weeks following surgery. Vaginitis occurs subsequent to such therapy, but adhesive stenosis can be prevented by periodic douching and dilatation over a period of two to three months. Vaginal extension and recurrence may be anticipated in about 6 to 10 per cent of carcinomas of the endometrium treated by intrauterine radium alone. Thirty-one patients with recurrence following surgery or radiotherapy performed elsewhere have been referred to us; of these, 16 showed involvement of the vagina. Vaginal recurrences localized to the vault can be effectively treated by transvaginal roentgen therapy in fractionated doses totaling about 6,000 r in two to three weeks, usually in combination with external roentgen therapy (Fig. 2). Mucosal lesions along the vaginal walls are better treated by radium placed in slotted or drilled radium applicators (Fig. 3) or by interstitial radium. The interstitial placement of

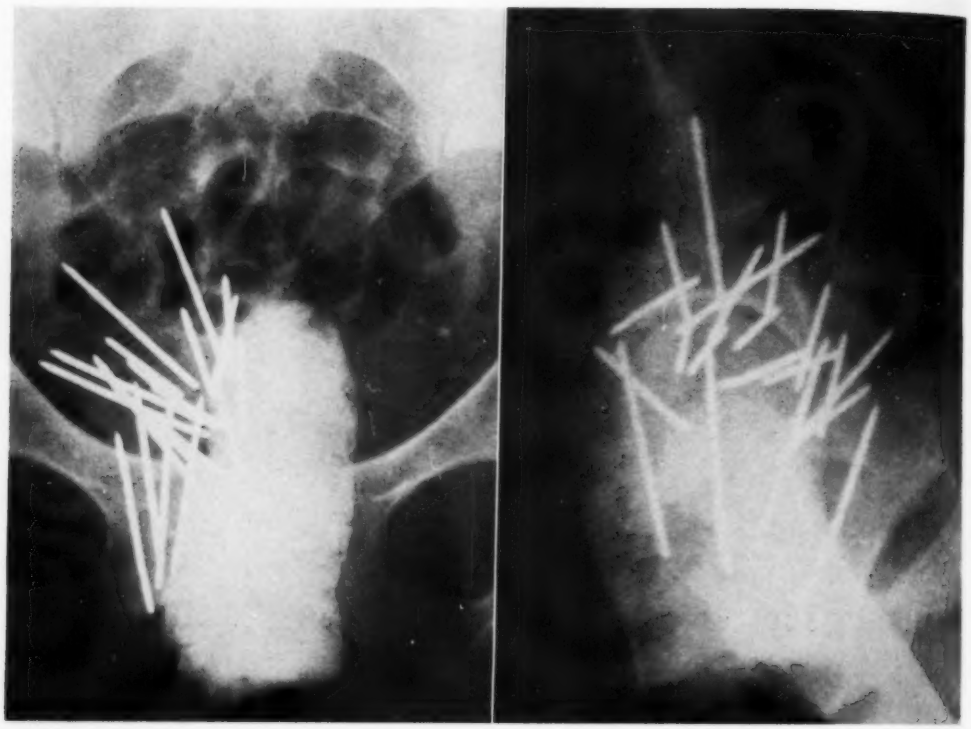

Fig. 4. Radium needle implantation for infiltrating paracervical recurrence of endocervical adenocarcinoma Patient well four years at time of report.

radium needles is particularly effective against lesions showing deeper paravaginal or paracervical extension (Fig. 4).

We have administered fractionated external roentgen therapy along with radium, that is, before, between, and occasionally after the radium applications without any intervening rest period. This extends the zone of cancerocidal dosage and improves the homogeneity of irradiation. The central area of radium application is shielded from the primary external radiation. The effectiveness of conventional roentgen therapy in endometrial carcinoma is often limited by obesity of the patient. Although some roentgen therapy is used in almost all cases, it is particularly valuable in large uteri with bulky tumors and in endocervical lesions. External therapy is essential in all cases treated by radiotherapy alone, in the treatment of Stage II cases with suspected extension beyond the uterus, and in postoperative cases with probable residual pelvic disease. The effectiveness of external roentgen therapy has been demonstrated by Lampe (21), who eliminated microscopic evidence of uterine carcinoma in 27 per cent of cases by delivery of 4,000 r through the pelvic region. His overall five-year survival rate for 70 patients irradiated in this manner, with subsequent hysterectomy, was 88.6 per cent. In general, nodal metastases and peripheral extensions may be expected to show the same radiosensitivity as the primary neoplasm.

Various criteria and points of reference have been proposed for calculation or measurement of combined radium and roentgen dosage in the treatment of endometrial carcinoma. Kottmeier (19, 20), advocates 2,650 gamma r delivered at the periphery of a zone 15 mm. beyond the uterine cavity, in two applications spaced

three weeks apart. Costolow and his associates (8) advise delivery of 5,400 gamma r in three weeks, or 6,000 r in four weeks, to an arbitrary point located 5 cm. above and 2.5 cm. lateral to the external os. Loeffler (23) proposed optimal geometric patterns for uteri of various sizes. In general, we try to deliver a total dose of 5,000 to 7,000 r to a zone 1.5 to 1 cm. beyond the periphery of the uterine cavity and upper vaginal tract. In endocervical carcinoma, 7,000 to 9,000 r are delivered at point A, 2 cm. above and 2 cm. lateral to the external os of the cervix. Dosage consists of radiation delivered by radium and x-ray during a period of three to six weeks.

Radiation dosimetry has the dual responsibility of delivering a homogeneous cancerocidal dose throughout the neoplasm and yet keeping irradiation of healthy tissues within the range of tolerance. Radiation delivered to the anterior rectal wall and posterior bladder can be actually measured by means of a scintillation probe roentgen meter such as that available through J. Townsend, 5942 Horton Place, St. Louis 12, Mo. In general, the rectal wall will not tolerate more than 5,000 r without proctitis; if surgery is to follow, the dose should not exceed 4,500 r in a six day period (Deeley, 9).

ANALYSIS OF CASE MATERIAL AND DISCUSSION

Attempts to evaluate the relative effectiveness of surgery, radiotherapy, and various combinations of treatment through comparison of five-year survival rates alone may be misleading. If survival rates are to be compared, not only must the case material be drawn from the same stage and type of disease but the patients must be of the same general age group and life expectancy, with similar components of intercurrent disease. Actually, case material from different clinics, or from the same clinic at different periods, will vary considerably with respect to age, general health, extent of disease, and modification by prior therapy. Even the suitability of cases for various types of surgery or radiotherapy is subject to significant preselection by referring physicians. Surgeons advocating hysterectomy for all endometrial carcinoma attract primarily operable cases with earlier lesions, while poorer risks and older patients with more advanced disease are referred to the radiotherapist. We ourselves refer good-risk patients with favorable lesions for post-irradiation hysterectomy while the poorer risks and patients with more advanced lesions remain in our statistics representative of the results of radiotherapy alone. Clinical staging of a lesion and even the histologic criteria for distinguishing between atypical hyperplasia and cancer differ from one physician or clinic to another. Such intangible variations in case material and in criteria for diagnosis and staging may influence the five-year survival rate even more than the relative effectiveness of the therapeutic procedures being evaluated.

TABLE I: CARCINOMA OF ENDOMETRIUM, ALL CASES. FIVE-YEAR SURVIVALS WITH DISTRIBUTION AS TO STAGE AND MODIFICATION BY PRIOR SURGERY OR RADIOTHERAPY

1937–49	Private Patients	Clinic Patients	Total Cases	5-Year Survivals
Stage I	30 (27)*	38 (29)	68	56 (82.3%)
Stage II	21 (7)	21 (4)	42	11 (26.2%)
All cases seen	51 (34)	59 (33)	110	67 (60.9%)
Modified	24 (13)	11 (5)	35	18 (51.4%)
Unmodified	27 (21)	48 (28)	75	49 (65.3%)

* Figures in parentheses indicate five-year survivals.

Table I summarizes the five-year survival rates for the 110 patients with endometrial carcinoma referred to us for radiotherapy during 1937–49 (59 state patients at the University of Nebraska Hospital and 51 private patients at the Nebraska Methodist Hospital). All cases were followed five years or more. Cases were staged according to the Stockholm Report as outlined by Kottmeier (19). No Stage 0 cases are included. Sixty-eight Stage I cases yielded a five-year survival rate of 82.3 per cent, while for 42 Stage II

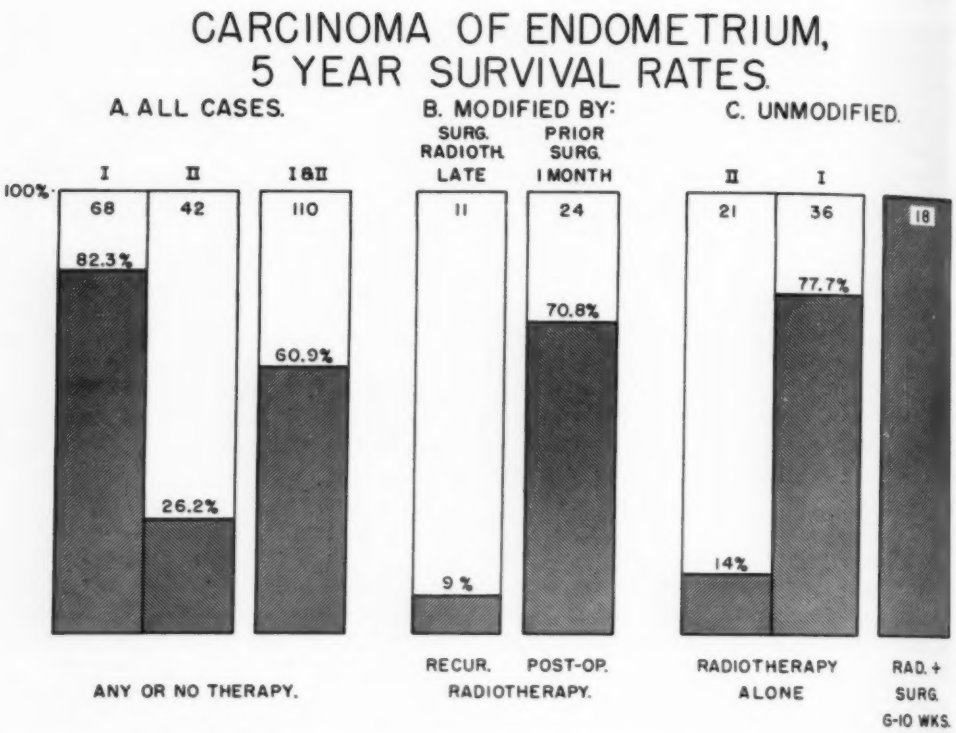

Fig. 5. Graphs showing absolute five-year survival rates for: (A) all cases, regardless of status or therapy; (B) cases modified by prior therapy, grouped as to late gross recurrence after surgery or irradiation elsewhere, and cases referred for radiotherapy within one month after subtotal or total hysterectomy; (C) unmodified cases grouped as to treatment by radiotherapy alone and radiotherapy followed by hysterosalpingo-oophorectomy.

cases the five-year survival rate was 26.2 per cent. The overall absolute five-year survival rate was 60.9 per cent. Thirty-five of the 110 cases had been modified by prior surgery or radiotherapy; 51.4 per cent of this group survived five years or more. The 75 unmodified cases had a five-year survival rate of 65.3 per cent (58.5 per cent for the University Clinic cases and 77.8 per cent for the private cases). In the clinic group the average age was sixty-four years; in the private group fifty-nine years.

Five-year survivals in the University Clinic group were reduced by 15 per cent as a result of deaths from intercurrent disease. The 9 deaths were due to the following causes: cardiac failure 3, cerebral hemorrhage 1, ruptured aneurysm 1, pulmonary embolism 1, leukemia 1, cancer of the breast 1, and cancer of the stomach 1. Deaths from intercurrent disease in the total group of 110 patients numbered 11, or 10 per cent during five years. The gross five-year survival rate for the private group of 51 cases was lowered by inclusion of 24 cases modified by prior therapy. Of these modified cases, 8 showed gross recurrence or metastases, and only 1 patient survived five years.

Radiotherapy alone, as shown in Table II, gave a five-year survival rate of 77.7 per cent for Stage I cases, while the rate for Stage II cases was only 14 per cent. The Stage II patients were older, with an average age of seventy, and showed a higher incidence of intercurrent disease as well as more advanced carcinoma. Our overall five-year survival rate from radiotherapy alone was 55 per cent.

TABLE II: CARCINOMA OF ENDOMETRIUM: UNMODIFIED CASES TREATED BY RADIOTHERAPY FOLLOWED BY HYSTEROSALPINGO-OOPHORECTOMY AND BY RADIOTHERAPY ALONE

1937–49	Av. Age	Private Patients	Clinic Patients	Total Cases	5-Year Survivals
Radiotherapy followed by surgery	56	6 (6)*	12 (12)	18	18 (90+%)
Radiotherapy alone: Stage I	60	12 (12)	24 (16)	36	28 (77.7%)
Radiotherapy alone: Stage II	70	9 (3)	12 (0)	21	3 (14%)
All unmodified cases	62	27 (21, or 78%)	48 (28, or 58%)	75	49 (65.3%)

* Figures in parentheses indicate five-year survivals.

Kottmeier (20) reported an absolute five-year survival rate of 57 per cent for all cases of endometrial carcinomas seen and treated primarily by radiotherapy at the Radiumhemmet. Post-irradiation hysterectomy was done in 16.3 per cent of the cases, supposed radiation failures. Kottmeier's survival rate would have been higher had a representative quota of early cases been referred to the Radiumhemmet instead of having been operated upon elsewhere in the vicinity of Stockholm, as happened in about 25 per cent of cases. This is comparable to the situation in Omaha, where many earlier cases were operated upon and never referred for irradiation. In our group of 57 patients given radiotherapy alone, 5 presented metastases beyond the pelvis at referral, and 3 of these received no significant irradiation. We now restrict radiotherapy, as the sole method of treatment, chiefly to patients with non-resectable cancer and those presenting serious operative risk or refusing surgery.

We have previously (24) advocated primary radium and roentgen therapy followed by hysterosalpingo-oophorectomy after six to twelve weeks in all operable cases. The advantages of post-irradiation surgery are elimination of any residual carcinoma in the uterus or ovaries and prevention of later recurrences. Bulky tumors in a large uterus, cancer deeply invading the myometrium, and lesions located in such recesses as the cornua or tubes are most prone to show residual carcinoma following usual radiotherapy. Oophorectomy as well as hysterosalpingectomy is essential, since carcinoma of the ovary occurs in about 6 per cent of patients with endometrial carcinoma, sometimes metastatic from the uterus and sometimes as a primary lesion. In the period 1937–49, 18 patients received radiotherapy followed by hysterosalpingo-oophorectomy and all survived at least five years. More extended use of hysterectomy after radiotherapy might well raise our five-year survival rates 10 to 15 per cent, particularly if a representative quota of earlier cases were referred to us initially instead of being operated upon elsewhere.

Many factors influence the incidence of residual carcinoma reported by the pathologist in uteri removed after radiotherapy. Thus, in large uteri containing bulky carcinomas and in the presence of myometrial involvement, more cancer remains, since the radium less closely approximates the periphery of the lesion. Only about 1 per cent of endometrial carcinomas involve the tubes and these are rarely controlled by radiotherapy. Adequacy and homogeneity of dosage are essential for the eradication of carcinoma; Arneson (3) considers a dose of 7,000 gamma r at a depth of 1.5 cm. mandatory. Resolution of carcinoma following radiotherapy requires six to twelve weeks; therefore, the earlier the hysterectomy and microscopic examination, the higher the reported incidence of residual cancer. Also, the more histologic sections made, the higher the incidence of observed cancer. The interpretative implications of residual atypical glands and ghost cells and the criteria for viability noted by the individual pathologist all affect the reported incidence of residual carcinoma. In general, the more favorable the case for hysterectomy, the more effective the radiotherapy and the lower the incidence of residual disease. Our incidence of residual carcinoma five or ten

TABLE III: COMPARISON OF FIVE-YEAR SURVIVAL RATES IN ENDOMETRIAL CARCINOMA TREATED BY SURGERY ALONE AND BY RADIOTHERAPY FOLLOWED BY HYSTERECTOMY

Author	Surgery Alone (per cent)	Radiotherapy Followed by Hysterectomy (per cent)
Arneson (3)		
Uteri over 12 cm.	33	52
Uteri under 12 cm.	79	87
Cosbie, Anderson, Millar, and Bunker (7)	72.9	84.6
Payne (29)	80.4	92.9
Randall, Mirick, and Wicben (30)	61.6	81.6
Schmitz (33)	78.5	90

years ago was only 10 per cent, while at present, with more and more cases subjected to post-irradiation surgery at shorter intervals, the figure has risen to between 25 and 30 per cent. This percentage could doubtless be further reduced by higher dosage with additional fractionation and protraction of treatment, and by delay of hysterectomy, although probably with little improvement of the overall five-year survival rate.

Radiotherapy followed in six to ten weeks by hysterosalpingo-oophorectomy has proved superior to surgery alone both in our experience and according to reports of the authors referred to in the first part of this presentation. Representative relative five-year survival rates from the literature are shown in Table III.

The relative five-year survival rates based on treatment of selected cases should not be confused with absolute survival rates which, by definition, must include at least all unmodified cases seen. Bastiaanse (4) reports an absolute five-year survival rate of 66.9 per cent for endometrial carcinoma treated by vaginal hysterectomy. McKelvey's five-year survival rate was 73 per cent following abdominal hysterectomy alone (25). But again attention is directed to the fact that many intangible factors besides the mode of therapy affect survival rates.

Preoperative radiotherapy provides more effective control of endometrial carcinoma than postoperative irradiation and, in many cases, is advantageous to the surgeon. Stage 0 cases are diagnostic and surgical problems. The very early, well differentiated Stage I carcinoma within a small uterus may be submitted to primary hysterosalpingo-oophorectomy, although Arneson (3) has shown the five-year survival rate to be 87 per cent with radiotherapy followed by hysterectomy as compared with only 79 per cent for hysterectomy alone in uteri measuring less than 12 cm. Intrauterine placement of radium, which is, of course, impossible after hysterectomy, provides not only effective irradiation of the primary intrauterine carcinoma but also significant irradiation of peripheral extensions and possible nodal metastases in the upper posterior pelvis. Adequate preoperative irradiation, through elimination of the primary carcinoma or devitalization of its cells, reduces the possibility of secondary implantation and spread during the operative procedure. At six to twelve weeks following radiotherapy, the uterus has become smaller and more mobile, congestion has subsided, and there are as yet no adhesions to interfere with hysterectomy. Operability of the patient can be improved by a reduction of weight, control of diabetes, and improvement of cardiovascular status. It must be clearly understood by the patient and agreed by her in advance that complete treatment involves hysterectomy as well as radiotherapy for optimal control of the disease.

Cases modified by prior hysterectomy or radiotherapy done elsewhere are presented in Table IV. Twenty-four patients were referred for radiotherapy within one month after surgery and 17 of these, or 70.8 per cent, survived five years or longer. The operative procedure in two-thirds of this group had been restricted to supravaginal hysterectomy, either on account of technical difficulties or because the diagnosis had been established only after surgery. The overall survival rate of this group would doubtless have been improved by more complete surgery and by more adequate application of intravaginal radium in *all* postoperative cases rather

TABLE IV: CARCINOMA OF ENDOMETRIUM: CASES MODIFIED BY RECENT SURGERY AND RECURRENT AFTER PRIOR SURGERY OR RADIOTHERAPY

1937–49	Av. Age	Private Patients	Clinic Patients	Total Cases	5-Year Survivals
Hysterectomy, with radiotherapy one month later (Stages I and II)	54	16 (12)*	8 (5)	24	17 (70.8%)
Recurrent after hysterectomy	62	5 (1)	2 (0)	7	1
Recurrent after radiotherapy	59	3 (0)	1 (0)	4	0
All modified cases	56	24 (13)	11 (5)	35	18 (51.4%)

* Figures in parentheses indicate five-year cures.

than primarily in those treated by subtotal hysterectomy. In general, the life expectancy of the postoperative group was relatively favorable, the average age being fifty-six years, or eight years less than in the group receiving radiotherapy alone. Lesions were primarily of Stage I, and few of the patients appeared to have intercurrent disease. Persistent or recurrent cancer limited to the cervical stump or vaginal mucosa, in postoperative or post-irradiated cases, can usually be controlled by local radiotherapy when recognized early and treated adequately. Seven patients were referred three months to five years after surgery, with gross recurrence and extension, and of these only 1 survived five years or more. Taylor and Becker (35) found the five-year survival rate for cases given immediate prophylactic radiotherapy to be 66.6 per cent, as compared to 24.8 per cent for cases referred with obvious persistent or recurrent cancer.

Salvage of patients in whom cancer persists or is recurrent following radiotherapy is possible only if the primary irradiation was inadequate or recent and incomplete. Localized vaginal recurrences may be controlled, but such recurrences are usually seen only in patients whose initial vaginal irradiation was insufficient. Recurring intrauterine cancer is best avoided by planned post-irradiation hysterectomy as advocated above. Re-irradiation of the uterine cavity is sometimes practical in inoperable patients who show persistent endometrial carcinoma at curettage performed six to eight weeks following the initial radiotherapy. Reactivation of intrauterine carcinoma six months and more after radiotherapy warrants renewed consideration of hysterectomy as advocated by Heyman and Kottmeier. If the disease is still limited to the pelvis, but is associated with extrauterine masses, or if there is involvement of the bladder or rectum, radical pelvic surgery is to be considered, as recommended by Brunschwig and Schmitz. Further irradiation may create complications, adding to the difficulty of radical surgery for persistent cancer, which is manageable, if at all, only by this latter means.

Careful long range follow-up of patients with endometrial carcinoma is essential, keeping in mind the possibilities of associated ovarian carcinoma, mammary carcinoma, diabetes, and cardiovascular disease as well as possible regional and distant metastases and, particularly, vaginal recurrence. Controllable vaginal recurrences may appear up to ten years following primary therapy and may be anticipated in 10 per cent of patients receiving little or no direct vaginal irradiation. The adequacy of intrauterine therapy may be checked by diagnostic curettage at six weeks when hysterectomy is not assured, thereby determining the necessity of further intrauterine radium at that time. Discovery of a parametrial or an ovarian mass increases the urgency of surgery. The late recurrence of intrauterine cancer following adequate primary radiotherapy always warrants reconsideration of surgery, particularly if the disease appears limited to the pelvis. Late metastases to pelvic nodes and infiltration about pelvic nerves are rarely controlled by radiotherapy, and the rate of salvage following radical surgery is discouragingly low (18). Pleural effusion due to metastatic endometrial

carcinoma has been restrained by radiogold for more than a year in 1 of our patients. Distant metastases rarely benefit from radiotherapy and seem little modified by chemotherapy or endocrine therapy.

SUMMARY

1. The ratio of endometrial to cervical uterine cancer is rising; in Omaha, Nebr., it is now 1 to 1.7. The overall death rate from uterine cancer is declining, now being 8.4 per 100,000 total population in Nebraska.

2. The absolute five-year survival rate for 110 consecutive patients with endometrial carcinoma referred for radiotherapy, followed five years and more, was 60.9 per cent, being 82.3 per cent for Stage I cases and 26.2 per cent for Stage II. Patients with early, well differentiated lesions treated primarily by surgery and not referred for radiotherapy have been excluded from this series.

3. Deaths from intercurrent disease occurred in 11 patients (10 per cent) during a five-year period, with 8 dying from cardiovascular disease and 3 from other primary cancers.

4. Cases unmodified by prior therapy had an absolute five-year survival rate of 65.3 per cent—58.3 per cent for the University Clinic cases and 77.8 per cent for private cases.

5. Primary radiotherapy, consisting of fractionated radium application in multiple intrauterine capsules and vaginal applicators, administered concurrently with external roentgen therapy, gave a five-year survival rate of 14 per cent for Stage II cases and 77.8 per cent for Stage I cases. Radiotherapy alone was limited for the most part to cases inoperable because of non-resectable and metastatic cancer, poor operative risks, and patients refusing therapy.

6. Subtotal or total hysterectomy followed within one month by intravaginal radium and external roentgen therapy gave a five-year survival rate of 70.8 per cent. Intravaginal radium is the most essential component of postoperative radiotherapy.

7. Optimal treatment consisted initially of combined radium and roentgen therapy, followed by hysterosalpingo-oophorectomy after six to twelve weeks in all operable cases. Eighteen selected patients were so treated, with 100 per cent five-year survivals.

8. Comparative five-year survival rates reflect not only the efficacy of the particular therapy under consideration but also differences in case material based on age, intercurrent disease, histology, stage of lesion, and modification by prior therapy. Such variations result from preselection of referred patients by attending physicians and further selection of post-irradiation hysterectomy according to criteria of operability.

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SUMARIO

Resultados Radioterapéuticos Comparativos en el Carcinoma del Endometrio Modificado por la Cirugía Anterior y la Histerosalpingo-Ovariectomía Postirradiatoria

El coeficiente absoluto de sobrevivencias de cinco años para 110 enfermas consecutivas (59 enfermas de clínica; 51 enfermas particulares) que padecían de carcinoma endométrico y recibidas para radioterapia, observadas durante cinco o más años, fué de 60.9 por ciento, siendo de 82.3 por ciento para los casos del Período I y de 26.2 por ciento para los del Período II. Hubo muertes debidas a afección intercurrente en 11 enfermas (10 por ciento), falleciendo 8 de afección cardiovascular y 3 de otro cáncer primario.

Setenta y cinco de los casos no habían sido modificados por terapéutica anterior y éstos mostraron un coeficiente absoluto de 65.3 por ciento de sobrevivencias de cinco años, con 58.3 por ciento para los

casos de clínica y 77.8 por ciento para los particulares. La curieterapia primaria, consistiendo en radio fraccionado en múltiples cápsulas intrauterinas y aplicadores vaginales, administrada junto con la roentgenoterapia externa, acusó un coeficiente de 14 por ciento de sobrevivencias de cinco años para los casos del Período II y de 77.8 por ciento para los del Período I. La radioterapia sola se limitó primordialmente a los casos de cáncer irresecable y metastático, a los malos riesgos operatorios y a casos en que la enferma rehusaba la cirugía. La radioterapia seguida de la histerosalpingo-ovariectomía elevó a 100 por ciento el coeficiente de sobrevivencias de cinco años.

Los casos modificados por el tratamiento anterior comprendieron 24 en que la histerectomía fué seguida de la radioterapia en término de un mes y 11 casos recurrentes después de una operación o irradiación anterior. Para los 24 casos en que la histerectomía subtotal o total fué seguida en término de un mes de la curieterapia vaginal y la roentgenoterapia externa, el coeficiente de sobrevivencias de cinco años fué de 70.8 por ciento. El radio intravaginal es el componente más indispensable de la radioterapia postoperatoria.

El tratamiento óptimo del carcinoma endométrico consiste en la curie- y la roentgenoterapia combinadas, seguidas de la histerosalpingo-ovariectomía al cabo de seis a doce semanas en todos los casos operables.

Los coeficientes comparativos de sobrevivencias de cinco años reflejan no sólo la eficacia de la terapéutica dada aquí considerada sino también las diferencias en el material clínico basadas en la edad, la enfermedad intercurrente, la histología, el período de la lesión y la modificación por el tratamiento anterior. Esas variaciones provienen de la preselección en los casos transmitidos por los médicos asistentes y la selección ulterior para la histerectomía postirradiatoria de acuerdo con las pautas de la operabilidad.

Calculation of Tissue Doses and Data for the Production of Isodose Charts, Using Standard Depth-Dose Tables[1]

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FOR SATISFACTORY dosage planning in radiotherapy, isodose charts are essential. Data for such charts can be obtained by measurements in unit-density phantoms, using suitable small ionization chambers, but this is a tedious procedure, with many possibilities for error. Many departments, therefore, prefer to use charts available through data exchange schemes such as the one operated by the British Hospital Physicists' Association, or by one or two groups in the United States. This is not entirely satisfactory, since it is seldom possible to obtain curves for all field shapes and radiation qualities desired, and adaptation is rather hazardous. On the other hand, the calculation of such data from available central-axis depth-dose tables is practicable, and several methods have been developed for the procedure (1, 4, 6–10). None of these has been widely employed in the United States, either because of lack of familiarity with them, or because the work involved seemed too great.

The basis for the calculation is the fact that the radiation arriving at a point in a scattering medium exposed to an x-ray beam is made up of two parts, that due to the primary beam, and that due to scattered radiation.

$$D = P + S$$

The primary contribution anywhere within the geometrical beam may be taken as that given for zero area, for the same irradiation conditions, and can be obtained from standard tables. The secondary contribution may be evaluated from a knowledge of scattered radiation values at the axis, obtained from published depth-dose data. For the evaluation several different formulae have been developed.

The method of Meredith and Neary (6) is straightforward and relatively simple to use, but their constants were based on the Mayneord and Lamerton *Survey of Depth Dose Data* of 1941 (5), while depth doses used in the United States are generally those in *Physical Foundations of Radiology* (2). Overall agreement between the two sets is not good enough to warrant using the old constants, nor even to be sure that the mathematical function developed by Meredith and Neary for expressing the scatter would hold for the new data.

Accordingly, one of us (W.J.M.) investigated this problem. It was thought that another function might better represent the data, but though a number were tried, none proved to be as satisfactory as that originally used. For fuller details concerning this, the reader is referred to the original paper of Meredith and Neary (6). The developments to be set forth here are based on their function, and on the depth-dose data in *Physical Foundations of Radiology*, except for the values of the primary radiation. These have been assembled from careful experimental measurements, checked by calculation.

It is the purpose of this paper to present as much basic data as possible in tabular form, and to follow through the simplified step-by-step developments of the various types of calculations, for individual points and for isodose charts, for both circular and rectangular fields. For the latter,

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TABLE I: VALUES OF THE PRIMARY RADIATION—*P*—ROENTGENS PER 100 r IN AIR

Depth	Half-Value Layer (mm. Cu)							Half-Value Layer (mm. Cu)						
	1	1.5	2	3	4	6	8	1	1.5	2	3	4	6	8
	50 cm. F.S.D.							80 cm. F.S.D.						
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1	80.0	80.3	80.6	81.9	83.2	84.6	86.2	81.2	81.6	81.8	83.1	84.4	85.9	87.4
2	64.2	64.6	64.9	67.0	69.2	71.7	74.2	66.2	66.6	66.9	69.2	71.4	73.9	76.5
3	51.6	52.0	52.5	55.2	57.8	60.8	64.2	53.8	54.3	54.8	57.6	60.3	63.4	67.0
4	41.4	41.8	42.3	45.4	48.1	51.7	54.5	43.4	44.0	44.7	47.9	51.1	54.8	58.6
5	33.2	33.8	34.3	37.2	40.2	43.8	47.9	35.6	36.2	36.8	40.0	43.1	47.0	51.4
6	26.8	27.2	27.6	30.6	33.6	37.1	41.4	29.0	29.4	29.9	33.2	36.5	40.3	45.0
7	21.7	22.1	22.5	25.2	28.0	31.7	35.9	23.9	24.3	24.7	27.8	30.8	34.8	39.4
8	17.3	17.7	18.1	20.8	23.5	26.7	30.9	19.2	19.7	20.1	23.1	26.1	29.7	34.4
9	13.9	14.5	15.1	17.4	19.6	23.0	26.8	15.7	16.4	17.0	19.6	22.1	25.9	30.2
10	11.2	11.6	11.9	14.2	16.4	19.4	23.3	12.8	13.2	13.6	16.2	18.7	22.1	26.5
12	7.3	7.6	7.9	9.7	11.5	14.2	17.6	8.5	8.8	9.1	11.2	13.4	16.6	20.5
14	4.8	5.0	5.2	6.6	8.1	10.3	13.2	5.6	5.9	6.2	7.9	9.6	12.2	15.6
16	3.1	3.2	3.4	4.6	5.7	7.5	10.0	3.7	3.9	4.1	5.5	6.9	9.1	12.1
18	2.1	2.2	2.3	3.2	4.1	5.5	7.6	2.5	2.6	2.8	3.9	5.0	6.7	9.4
20	1.3	1.4	1.5	2.2	2.8	4.0	5.8	1.7	1.8	1.9	2.8	3.6	5.1	7.2
	70 cm. F.S.D.							100 cm. F.S.D.						
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1	80.8	81.1	81.4	82.7	84.0	85.4	87.0	81.6	81.9	82.2	83.6	84.9	86.3	87.9
2	65.6	66.0	66.4	68.6	70.8	73.2	75.9	66.8	67.2	67.6	69.8	72.1	74.6	77.3
3	53.2	53.8	54.3	57.0	59.7	62.9	66.3	54.5	55.0	55.6	58.4	61.1	64.3	67.9
4	43.3	43.7	44.1	47.2	50.3	54.0	57.8	44.7	45.2	45.6	48.8	52.0	55.8	59.7
5	35.1	35.6	36.2	39.4	42.5	46.2	50.6	36.5	37.0	37.6	40.9	44.2	48.1	52.6
6	28.5	28.9	29.3	32.6	35.8	39.6	44.1	29.9	30.4	30.8	34.2	37.5	41.4	46.2
7	23.3	23.7	24.1	27.0	30.0	34.0	38.4	24.6	25.0	25.5	28.6	31.8	36.0	40.7
8	18.7	19.2	19.6	22.5	25.4	29.0	33.5	20.0	20.4	20.9	24.0	27.1	30.8	35.7
9	15.2	15.9	16.6	19.0	21.4	25.1	29.4	16.3	17.0	17.7	20.4	23.0	26.9	31.4
10	12.4	12.7	13.1	15.6	18.1	21.4	25.6	13.4	13.8	14.2	16.9	19.6	23.1	27.8
12	8.0	8.4	8.8	10.4	12.9	15.9	19.7	8.9	9.2	9.6	11.8	14.1	17.5	21.6
14	5.4	5.7	6.0	7.6	9.2	11.7	15.0	6.0	6.3	6.6	8.4	10.2	13.0	16.6
16	3.6	3.8	3.9	5.2	6.6	8.7	11.6	4.0	4.2	4.4	5.9	7.4	9.7	13.0
18	2.4	2.5	2.6	3.6	4.7	6.4	8.9	2.7	2.8	3.0	4.2	5.4	7.3	10.1
20	1.6	1.7	1.8	2.6	3.4	4.8	6.8	1.8	2.0	2.1	3.0	3.9	5.5	7.8

the authors are indebted to R. G. Mitchell, who has kindly permitted reproduction of his calculated values of the scatter integrals for such fields (7, 8).

In Table I are given values of the primary radiation, *P*, in roentgens per 100 r in air at the position of the skin, for a wide range of qualities and for focal-skin distances of 50, 70, 80, and 100 cm.

DOSES IN CIRCULAR FIELDS

The scattered radiation at the center of a circular field, at any depth, may be represented by the function

$$S = f(r) = M[1 - \lambda r K_1(\lambda r)]$$

where r is the radius of the field at the depth under consideration and K_1 is the modified Bessel function of the second kind of order 1. M and λ are arbitrary constants determined for each set of irradiation conditions to give the best fit to the experimental central-axis scatter data. (For precise details see Meredith and Neary.) The former constant varies with beam quality, focal-skin distance, and depth. The latter, is always used in the form $\lambda \frac{f + d}{f}$, and depends only on quality and depth over a wide range of focal-skin distances.

The central-axis scatter value (S) for any field and depth is given by $S = D - P$, where D and P are, respectively, for 100 r in air at the position of the skin, the depth dose for the field and the primary dose (Table I). Where the scatter values are small, irregularities may exist in tables, since the depth doses were published only in whole numbers. Therefore, the values

obtained by subtraction were plotted for all depths according to field size, and for all fields according to depth, for each quality of radiation. Values were read from these curves and averaged for use in calculation of constants.

For the production of isodose curves, scatter values for points off the central axis will also be necessary, and such points may be defined according to the reference frame shown in Figure 1.

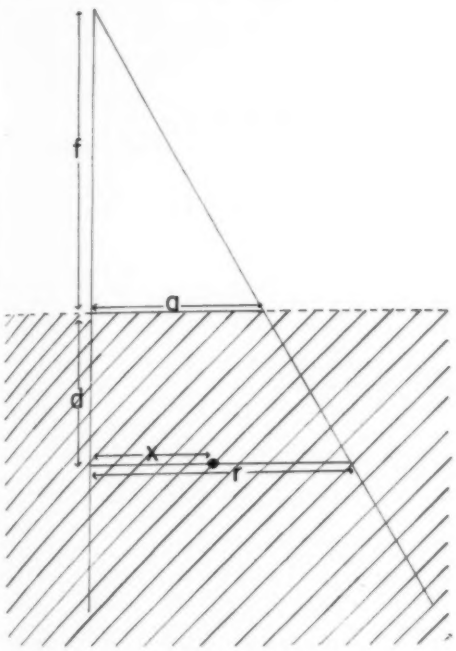

Fig. 1. Diagram showing symbols used in dosage calculations.

f = focal-skin distance
d = depth of point under consideration
a = radius of field at surface
r = radius of field at depth d
$= a\dfrac{f+d}{f}$
x = distance from central axis to point under consideration
$k = x/r$
$\lambda r = \lambda\dfrac{f+d}{f}a$

The scattered radiation reaching any point in such a frame can be written $S = MI_s$, where I_s, the scatter integral for circular fields, can be obtained by integration from the basic scatter function. (For further details see Meredith and Neary.) Values of I_s, which depends on λr and k, are given in Table II, while the values of $\lambda\dfrac{f+d}{f}$ and M are set out in Tables III and IV, respectively.

To obtain the values for the scattered radiation at a specific point in a particular circular field, it is necessary only to find the pertinent value of I_s and multiply by the appropriate M. For example, to find the dose at a point 5 cm. deep and 2 cm. from the axis in a circular beam 6 cm. in diameter, for h.v.l. 2.0 mm. Cu, and 50 cm. F.S.D.:

$$a = 3 \qquad r = a\frac{f+d}{f} = 3 \times \frac{55}{50} = 3.3$$

$$x = 2 \qquad k = x/r = 2/3.3 = 0.6$$

$$\lambda\frac{f+d}{f} = 0.342 \text{ (Table III)}$$

$$\lambda r = \lambda\frac{f+d}{f}\,a = 0.342 \times 3 = 1.026$$

$I_s = 0.349$ (Table II, for $k = 0.6$ and $\lambda r = 1.026$)

$M = 65.0$ (Table IV)

$S = MI_s = 65.0 \times 0.349 = 22.7$

$P = 34.3$ (Table I)

$D = 34.3 + 22.7 = 57.0$ r per 100 r in air

For a series of points for isodose chart development, the calculation is accomplished in a straightforward manner by setting up such a tabulation as that in Table V. The operations are carried out in the following stages:

1. List depths at which doses are to be determined, in column 1.
2. For the relevant physical constants, obtain values $\lambda\dfrac{f+d}{f}$ from Table III and enter in column 2.
3. Multiply each of these by a, to get λr; enter values in column 3.
4. Using these values of λr, and $k = 0$, obtain values of I_0 from Table II; enter in column 4.

TABLE II: VALUES OF SCATTER INTEGRAL FOR CIRCULAR FIELDS, I_s

	← $k = x/r$ →															
λr	0	0.2	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.10	1.20	1.30	1.40	1.60
0.1	0.015	0.015	0.014	0.014	0.014	0.013	0.013	0.013	0.012	0.012	0.012	0.012	0.011	0.011	0.010	0.010
0.2	0.045	0.044	0.043	0.042	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.033	0.032	0.030	0.029	0.026
0.3	0.083	0.082	0.080	0.078	0.076	0.072	0.070	0.067	0.064	0.062	0.060	0.058	0.055	0.052	0.049	0.043
0.4	0.126	0.125	0.121	0.117	0.112	0.108	0.102	0.097	0.094	0.091	0.088	0.084	0.078	0.072	0.067	0.059
0.5	0.172	0.170	0.164	0.159	0.154	0.145	0.138	0.129	0.124	0.119	0.114	0.109	0.100	0.092	0.085	0.073
0.6	0.218	0.216	0.207	0.201	0.193	0.182	0.173	0.160	0.153	0.146	0.139	0.133	0.120	0.112	0.100	0.084
0.7	0.265	0.261	0.250	0.242	0.232	0.219	0.206	0.190	0.181	0.172	0.163	0.154	0.138	0.125	0.112	0.093
0.8	0.311	0.306	0.293	0.282	0.270	0.255	0.238	0.218	0.207	0.196	0.184	0.174	0.154	0.139	0.123	0.099
0.9	0.355	0.350	0.334	0.321	0.306	0.288	0.269	0.245	0.232	0.218	0.204	0.191	0.168	0.150	0.131	0.103
1.0	0.398	0.392	0.374	0.358	0.343	0.319	0.298	0.270	0.254	0.238	0.222	0.207	0.180	0.158	0.138	0.106
1.2	0.479	0.469	0.446	0.427	0.407	0.378	0.350	0.314	0.294	0.272	0.250	0.232	0.197	0.172	0.145	0.107
1.4	0.550	0.539	0.515	0.492	0.467	0.432	0.398	0.352	0.328	0.301	0.275	0.252	0.209	0.180	0.148	0.105
1.6	0.613	0.601	0.572	0.549	0.520	0.483	0.440	0.385	0.358	0.326	0.293	0.267	0.218	0.184	0.147	0.100
1.8	0.671	0.658	0.626	0.599	0.567	0.524	0.478	0.418	0.383	0.346	0.308	0.276	0.221	0.184	0.144	0.095
2.0	0.720	0.709	0.674	0.646	0.610	0.564	0.510	0.444	0.405	0.362	0.321	0.284	0.222	0.183	0.139	0.088
2.2	0.759	0.748	0.716	0.687	0.649	0.601	0.542	0.469	0.426	0.372	0.330	0.288	0.221	0.178	0.134	0.082
2.4	0.797	0.785	0.751	0.722	0.679	0.630	0.568	0.488	0.441	0.379	0.335	0.290	0.220	0.173	0.126	0.076
2.6	0.830	0.818	0.781	0.746	0.710	0.651	0.591	0.505	0.454	0.397	0.340	0.293	0.217	0.168	0.119	0.068
2.8	0.855	0.844	0.808	0.773	0.737	0.675	0.613	0.522	0.468	0.405	0.344	0.293	0.212	0.163	0.114	0.062
3.0	0.880	0.868	0.832	0.797	0.760	0.697	0.633	0.537	0.479	0.412	0.347	0.292	0.208	0.158	0.108	0.054
3.25	0.902	0.889	0.856	0.820	0.785	0.720	0.656	0.554	0.492	0.419	0.348	0.290	0.201	0.150	0.101	0.048
3.5	0.922	0.910	0.879	0.844	0.810	0.744	0.678	0.570	0.505	0.426	0.349	0.288	0.194	0.143	0.094	0.042
4.0	0.950	0.942	0.913	0.880	0.848	0.780	0.713	0.599	0.525	0.436	0.349	0.281	0.180	0.128	0.079	0.032
5.0	0.980	0.974	0.954	0.926	0.901	0.836	0.771	0.646	0.559	0.449	0.344	0.260	0.151	0.101	0.048	0.018
6.0	0.992	0.989	0.982	0.958	0.935	0.876	0.816	0.685	0.586	0.456	0.343	0.242	0.127	0.081	0.035	0.010

TABLE III: VALUES OF THE CONSTANT $\lambda \frac{f+d}{f}$

Depth (cm.)	Half Value Layer (mm. Cu)						
	1	1.5	2	3	4	6	8
0	0.385	0.385	0.385	0.369	0.346	0.300	0.290
1	0.412	0.420	0.426	0.414	0.390	0.355	0.360
2	0.381	0.384	0.387	0.398	0.399	0.390	0.410
3	0.352	0.362	0.370	0.378	0.391	0.396	0.425
4	0.328	0.344	0.355	0.370	0.379	0.388	0.414
5	0.308	0.328	0.342	0.357	0.367	0.376	0.400
6	0.293	0.313	0.330	0.345	0.355	0.364	0.387
7	0.280	0.305	0.319	0.335	0.345	0.352	0.375
8	0.270	0.293	0.308	0.323	0.334	0.341	0.365
9	0.260	0.285	0.299	0.314	0.324	0.330	0.356
10	0.250	0.272	0.288	0.303	0.314	0.321	0.347
12	0.232	0.257	0.270	0.286	0.296	0.302	0.333
14	0.216	0.237	0.252	0.267	0.278	0.284	0.320
16	0.200	0.220	0.235	0.249	0.260	0.267	0.308
18	0.184	0.203	0.218	0.232	0.241	0.250	0.296
20	0.170	0.188	0.201	0.215	0.222	0.233	0.284

TABLE IV: VALUES OF THE CONSTANT M

F.S.D. (cm.)	1.0 mm. Cu h.v.l.			1.5 mm. Cu h.v.l.			2.0 mm. Cu h.v.l.			3.0 mm. Cu h.v.l.		
	50	70	80	50	70	80	50	70	80	50	70	80
Depth (cm.)												
0	49.0	49.0	49.0	40.6	40.6	40.6	36.2	36.2	36.2	32.0	32.0	32.0
1	70.0	70.0	70.0	59.4	59.6	59.9	54.5	55.2	55.8	49.5	49.7	49.8
2	77.6	80.8	81.2	70.5	70.7	74.5	61.9	65.9	69.1	58.5	59.3	60.7
3	80.0	83.2	84.7	73.0	73.5	77.2	65.0	68.4	71.3	61.0	61.5	63.0
4	79.8	83.6	84.0	71.3	74.0	77.2	65.8	67.8	71.9	59.5	61.3	63.3
5	77.6	81.9	82.3	69.4	73.5	76.0	65.0	66.5	70.8	58.2	60.5	62.7
6	74.2	78.6	79.4	67.5	68.7	73.2	63.4	64.6	68.7	56.8	59.2	61.5
7	70.0	74.6	75.3	63.7	66.5	69.4	60.0	62.0	65.6	54.1	56.6	60.3
8	65.2	69.2	70.4	61.0	62.9	65.9	57.0	59.2	62.8	52.0	54.6	58.1
9	60.5	64.8	65.7	56.5	59.5	62.5	53.5	56.2	59.9	48.9	52.4	55.7
10	54.0	59.8	61.5	51.6	55.3	58.5	49.6	52.6	56.1	45.9	49.4	52.1
12	47.0	50.2	52.6	44.5	47.5	51.0	42.8	45.6	49.4	39.5	43.0	46.0
14	38.4	41.8	44.7	38.4	41.6	44.1	38.3	41.3	43.4	35.0	38.9	40.6
16	30.9	34.8	37.6	31.6	35.8	38.0	32.3	35.9	37.8	30.2	34.4	35.7
18	24.3	28.9	31.5	25.9	29.9	32.6	26.9	30.0	32.9	25.4	29.0	30.8
20	19.7	24.1	26.3	21.8	25.4	28.0	22.2	26.0	28.6	22.0	25.9	27.5

F.S.D. (cm.)	4.0 mm. Cu h.v.l.				6.0 mm. Cu h.v.l.				8.0 mm. Cu h.v.l.			
	50	70	80	100	50	70	80	100	50	70	80	100
Depth (cm.)												
0	28.7	28.7	28.7	28.7	22.8	22.8	22.8	22.8	19.6	19.6	19.6	19.6
1	45.0	45.1	45.3	45.5	36.0	37.5	38.0	38.8	31.3	31.8	32.0	32.1
2	53.2	54.1	54.6	54.9	45.0	47.0	47.5	47.8	38.9	40.5	41.2	41.5
3	54.4	56.4	57.2	58.4	46.6	48.8	49.2	51.8	41.8	43.7	44.4	45.1
4	54.6	56.5	57.6	60.3	46.8	50.5	49.8	53.3	42.3	45.4	46.2	46.5
5	53.4	55.7	57.2	60.7	46.4	49.5	50.1	53.8	42.2	45.5	46.7	46.8
6	51.8	55.1	56.8	59.9	45.5	49.0	49.8	53.2	41.7	44.0	45.4	46.4
7	49.8	52.7	56.4	57.7	44.4	47.2	49.2	51.8	40.3	43.3	44.0	45.9
8	47.6	51.2	54.9	55.5	43.1	45.8	47.4	50.2	39.0	41.6	43.0	45.0
9	45.6	50.2	52.1	52.7	41.4	44.9	45.9	48.2	37.2	40.5	41.8	43.4
10	43.1	47.5	49.2	50.1	39.4	43.2	44.7	46.0	35.3	38.6	40.0	41.8
12	37.4	41.3	42.8	44.8	35.5	38.3	40.4	41.6	31.5	34.7	36.2	38.4
14	32.2	35.7	37.4	39.9	31.2	33.0	36.7	37.4	27.7	31.0	32.4	34.8
16	27.4	31.1	32.7	35.0	27.2	27.9	32.6	33.1	24.0	27.0	28.8	31.2
18	24.0	27.0	28.6	31.4	23.3	24.4	28.8	29.4	20.8	23.9	25.3	27.5
20	21.0	24.6	26.5	27.7	19.6	21.3	25.2	26.0	17.4	20.4	22.0	24.4

TABLE V: CALCULATED DATA FOR ISODOSE CHART. 7 CM. DIAMETER CIRCULAR FIELD. 50 cm. F.S.D. h.v.l. 1.5 mm. Cu. $a = 3.5$ cm.

1	2	3	4	5	6	7	8	9
Depth (cm.)	$\lambda\left(\frac{f+d}{f}\right)$	λr	I_0	M	S_0	P	D_0	r
0	0.385	1.35	0.532	40.6	21.6	100.0	121.6	3.50
1	0.420	1.47	0.572	59.4	33.9	80.3	114.2	3.57
3	0.362	1.27	0.505	73.0	36.9	52.0	88.9	3.71
5	0.328	1.15	0.460	69.4	31.9	33.8	65.7	3.85
10	0.272	0.952	0.378	51.6	19.5	11.6	31.1	4.20
14	0.237	0.829	0.322	38.4	12.3	5.0	17.3	4.48
20	0.188	0.658	0.246	21.8	5.4	1.4	6.8	4.90

	$x = 1$				$x = 2.5$			
1	10	11	12	13	14	15	16	17
Depth (cm.)	k_1	I_1	S_1	D_1	$k_{2.5}$	$I_{2.5}$	$S_{2.5}$	$D_{2.5}$
0	0.286	0.512	20.8	120.8	0.715	0.415	16.8	116.8
1	0.280	0.549	32.6	112.9	0.700	0.450	26.7	107.0
3	0.270	0.486	35.4	87.4	0.675	0.406	29.6	81.6
5	0.260	0.443	30.8	64.6	0.650	0.377	26.2	60.0
10	0.238	0.366	18.9	30.5	0.595	0.325	16.8	28.4
14	0.223	0.314	12.1	17.1	0.558	0.286	11.0	16.0
20	0.204	0.240	5.2	6.6	0.510	0.224	4.9	6.3

	$x = 3.5$				$x = 5$			
1	18	19	20	21	22	23	24	25
Depth (cm.)	$k_{3.5}$	$I_{3.5}$	$S_{3.5}$	$D_{3.5}$	k_5	I_5	S_5	D_5*
0	1.000	0.294	11.9	111.9	1.430	0.142	5.8	5.8
1	0.980	0.322	19.1	99.4	1.400	0.148	8.8	8.8
3	0.945	0.309	22.6	74.6	1.350	0.160	11.7	11.7
5	0.911	0.300	20.8	54.6	1.300	0.168	11.7	11.7
10	0.835	0.273	14.1	25.7	1.190	0.177	9.2	9.2
14	0.780	0.248	9.5	14.5	1.115	0.174	6.7	6.7
20	0.714	0.200	4.4	5.8	1.020	0.160	3.5	3.5

* No primary radiation for points outside geometric beam. The calculations for $x = 6$ are not shown, but the results have been included in Figure 2.

5. Obtain values of M from Table IV; enter in column 5.
6. Calculate $S_0 = I_0 \times M$; enter in column 6.
7. Obtain values of P from Table I; enter in column 7.
8. Calculate $D_0 = S_0 + P$; enter in column 8. If the field being investigated is one for which central axis values are tabulated, the values obtained by the procedure outlined should agree closely with the relevant values in the table. Thus, an internal check on the calculations may be established. Now, for points off the axis, proceed as in remainder of Table V.
9. Calculate r for each depth $\left(=\frac{f+d}{f}a\right)$; enter in column 9. From here on, for each distance, x, out from the axis, four columns are necessary.
10. For each distance, calculate $k_x = x/r$; list in columns 10, 14, etc.
11. Obtain I_x from Table II, using the same λr's as before, and the appropriate k's; enter in columns 11, 15, etc. (This may require considerable interpolation. It is often convenient to plot the data of Table II with I and λr as variables, and k as a parameter for the various curves.)

TABLE VI: ALTERNATIVE METHOD OF ISODOSE CALCULATION. SAME PHYSICAL FACTORS AS TABLE V.

Depth (cm.)	λr	M	P	$k = 0.2$				$k = 0.6$			
				$I_{0\text{-}2}$	$S_{0\text{-}2}$	$D_{0\text{-}2}$	$x_{0\text{-}2}$	$I_{0\text{-}6}$	$S_{0\text{-}6}$	$D_{0\text{-}6}$	$x_{0\text{-}6}$
0	1.35	40.6	100	0.522	21.2	121.2	0.70	0.451	18.3	118.3	2.10
1	1.47	59.4	80.3	0.562	33.4	113.7	0.71	0.487	28.9	109.2	2.14
3	1.27	73.0	52.0	0.494	36.1	88.1	0.74	0.428	31.2	83.2	2.23
5	1.15	69.4	33.8	0.450	31.2	65.0	0.77	0.392	27.2	61.0	2.31

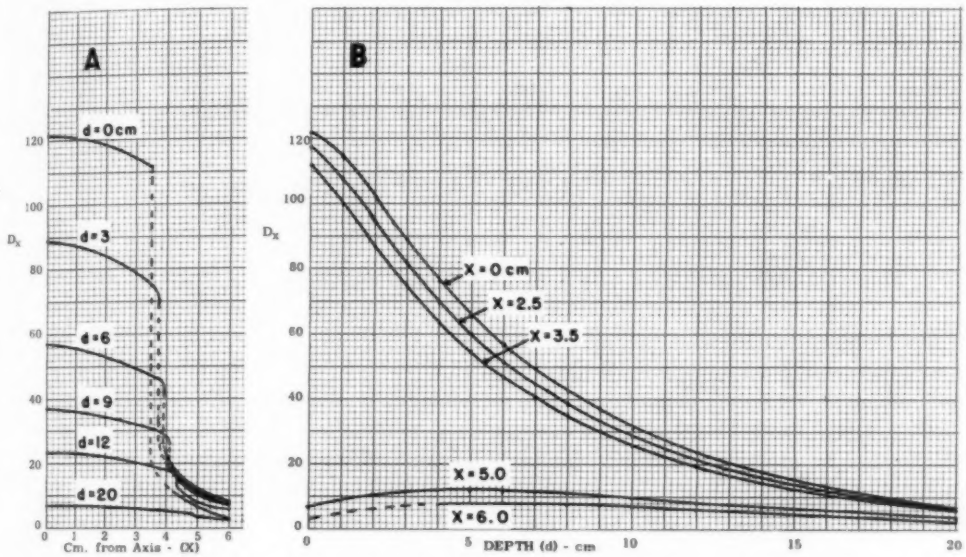

Fig. 2. Curves indicating method of plotting calculated values to obtain data for isodose charts.

12. Calculate $S_x = MI_x$; enter in columns 12, 16, etc.
13. Calculate $D_x = P + S_x$; enter in columns 13, 17, etc. (Be sure not to include P-values for points outside the geometrical beam.)
14. Plot the data for D_x in two sets of curves, as shown in Figure 2.
15. Draw an outline of the beam, in actual size, on centimeter-squared graph paper; indicate positions of lines $x = 0$, $x = 1$, etc., as indicated in Figure 3.
16. Select in turn values of D_x (100, 90, 80, etc.) For each one:
    (*a*) From Figure 2A, find the distance out from the axis at which this value lies on each d-curve. Indicate this point at the same distance out, at the corresponding depth in Figure 3. (Circles indicate these values for D_x = 80 and 50.)
    (*b*) From Figure 2B, find the depth at which the value lies, for each x-curve. Indicate the point at the corresponding position on Figure 3. (Crosses indicate these values.)
17. Draw smooth curves through all points for each specific value. The result is the finished isodose chart for the beam in question.

In Figure 4 is shown the calculated chart for the beam which has just served as an example, as well as one for the same beam, as published by Johns (3). The agreement is good. It would not be expected to be perfect, because Johns' mid-line doses differ somewhat from those used in developing the constants employed here. Where measured axial doses agree with those in *Physical Foundations of Radiology*, excellent agreement should be obtained between measured and calculated

TABLE VII: VALUES OF SCATTER INTEGRALS FOR SQUARE FIELDS

	← $k = x/p'$ →														
$\lambda p'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5
0.1	0.016	0.016	0.016	0.016	0.015	0.015	0.015	0.015	0.015	0.014	0.014	0.014	0.014	0.014	0.014
0.2	0.055	0.054	0.054	0.052	0.051	0.050	0.048	0.046	0.044	0.042	0.039	0.037	0.036	0.035	0.034
0.3	0.103	0.101	0.099	0.094	0.092	0.089	0.086	0.082	0.078	0.074	0.070	0.068	0.064	0.059	0.057
0.4	0.149	0.146	0.143	0.137	0.132	0.128	0.123	0.128	0.112	0.106	0.101	0.096	0.090	0.084	0.076
0.5	0.202	0.197	0.192	0.182	0.174	0.168	0.160	0.153	0.146	0.140	0.133	0.124	0.115	0.106	0.098
0.6	0.252	0.256	0.241	0.226	0.217	0.208	0.198	0.188	0.179	0.171	0.163	0.150	0.137	0.126	0.115
0.7	0.304	0.296	0.287	0.265	0.254	0.244	0.234	0.221	0.208	0.199	0.190	0.173	0.154	0.139	0.129
0.8	0.355	0.344	0.333	0.307	0.294	0.282	0.264	0.252	0.239	0.226	0.214	0.192	0.169	0.152	0.141
0.9	0.403	0.391	0.379	0.349	0.333	0.317	0.293	0.280	0.266	0.250	0.234	0.209	0.183	0.162	0.150
1.0	0.447	0.436	0.425	0.391	0.372	0.352	0.322	0.306	0.290	0.272	0.253	0.224	0.194	0.170	0.157
1.2	0.527	0.514	0.500	0.464	0.437	0.410	0.372	0.350	0.328	0.300	0.272	0.246	0.209	0.181	0.160
1.4	0.602	0.586	0.570	0.526	0.494	0.461	0.415	0.388	0.361	0.326	0.290	0.262	0.216	0.188	0.160
1.6	0.666	0.648	0.631	0.580	0.542	0.505	0.453	0.420	0.388	0.348	0.309	0.270	0.224	0.190	0.156
1.8	0.721	0.702	0.682	0.627	0.586	0.544	0.484	0.447	0.410	0.368	0.327	0.274	0.225	0.188	0.149
2.0	0.768	0.748	0.727	0.671	0.576	0.580	0.510	0.468	0.426	0.384	0.343	0.276	0.222	0.180	0.140
2.2	0.808	0.787	0.766	0.708	0.659	0.610	0.534	0.486	0.439	0.396	0.353	0.278	0.216	0.168	0.129
2.4	0.842	0.822	0.801	0.741	0.689	0.638	0.553	0.502	0.451	0.404	0.358	0.279	0.208	0.158	0.120
2.6	0.870	0.850	0.830	0.769	0.716	0.662	0.571	0.516	0.461	0.410	0.358	0.279	0.201	0.148	0.112
2.8	0.892	0.873	0.854	0.792	0.736	0.680	0.586	0.527	0.468	0.412	0.356	0.278	0.193	0.140	0.105
3.0	0.910	0.892	0.873	0.810	0.752	0.695	0.600	0.536	0.473	0.411	0.348	0.256	0.186	0.132	0.097
3.25	0.924	0.906	0.889	0.830	0.771	0.712	0.614	0.546	0.478	0.410	0.343	0.248	0.176	0.123	0.089
3.5	0.938	0.922	0.905	0.849	0.790	0.730	0.627	0.554	0.482	0.410	0.338	0.240	0.167	0.114	0.080
4.0	0.965	0.951	0.937	0.888	0.827	0.766	0.654	0.572	0.490	0.409	0.328	0.225	0.144	0.097	0.064
5.0	0.985	0.974	0.964	0.922	0.856	0.811	0.695	0.596	0.496	0.398	0.301	0.182	0.110	0.060	0.038
6.0	0.990	0.985	0.980	0.955	0.898	0.841	0.722	0.611	0.500	0.386	0.273	0.151	0.083	0.024	0.015

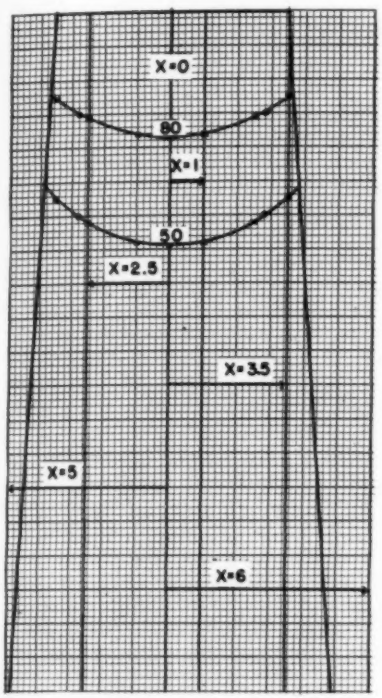

Fig. 3. Construction of isodose chart.

isodose charts, unless the experimental diaphragm system is unusual.

An alternative method of calculation, from step 8 on, is to select definite values of k(= 0.2, 0.4, 0.6, etc.) instead of definite x's. Since $k = x/r$ all x's for a given k will lie on a straight line at a constant fraction of the radius out from the axis, whose prolongation would pass through the focus. Its position can be determined by calculating any two values of x. This method requires much less interpolation in Table II, since tabulated values of k can be selected. If tabulated values for the chosen k's are plotted against λr, it is easy to read values for intermediate λr's. The time spent in plotting the curves is easily saved on the overall calculation.

A section of such a calculation is shown in Table VI. Values of D obtained in this manner are plotted as before, but now the parameter for the set of curves corresponding to Figure 2B will be k instead of x. Then, in plotting the isodose chart, a series of lines at positions corresponding

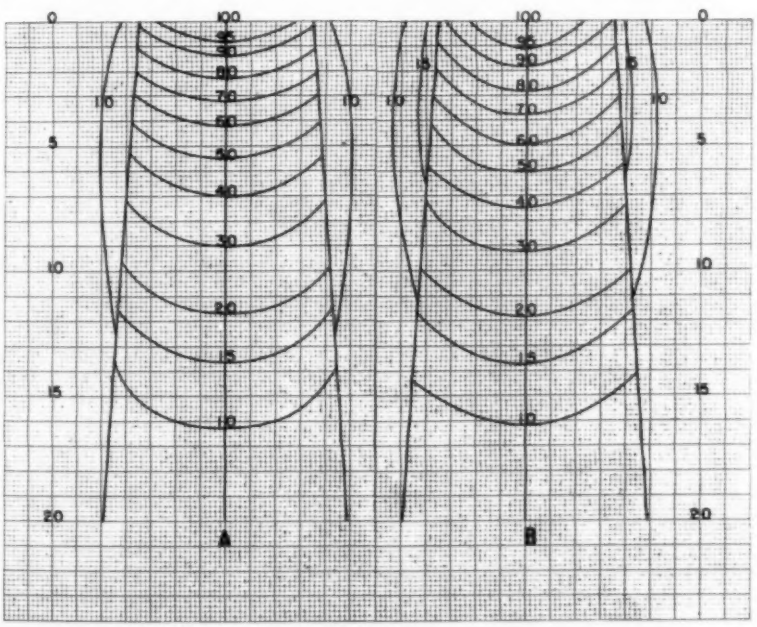

Fig. 4. Isodose charts for circular field 7 cm. in diameter; 50 cm. F.S.D., h.v.l. 1.5 mm. Cu. A. Calculated. B. Published by Johns (Physics of Radiation Therapy, p. 258). Reproduced by courtesy of H. E. Johns and Charles C Thomas, publisher.

TABLE VIII-A: VALUES OF SCATTER INTEGRALS FOR RECTANGULAR FIELDS. RATIO OF SIDES 1.25:1. LONG AXIS.

	← $k = x/q'$ →														
$\lambda p'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5
0.1	0.028	0.028	0.028	0.027	0.026	0.025	0.024	0.024	0.023	0.022	0.020	0.020	0.019	0.018	0.017
0.2	0.065	0.064	0.063	0.060	0.060	0.059	0.056	0.053	0.050	0.048	0.045	0.043	0.041	0.040	0.038
0.3	0.113	0.111	0.109	0.108	0.104	0.101	0.098	0.092	0.086	0.072	0.078	0.076	0.069	0.066	0.062
0.4	0.172	0.168	0.165	0.156	0.149	0.142	0.137	0.130	0.124	0.117	0.110	0.106	0.095	0.088	0.080
0.5	0.228	0.224	0.219	0.207	0.196	0.186	0.177	0.168	0.160	0.151	0.142	0.132	0.117	0.108	0.098
0.6	0.288	0.281	0.274	0.257	0.244	0.230	0.215	0.204	0.192	0.182	0.172	0.154	0.138	0.125	0.111
0.7	0.338	0.330	0.321	0.299	0.286	0.273	0.248	0.236	0.223	0.210	0.196	0.174	0.156	0.137	0.122
0.8	0.391	0.381	0.371	0.344	0.328	0.312	0.282	0.266	0.250	0.234	0.218	0.192	0.168	0.146	0.129
0.9	0.443	0.431	0.419	0.388	0.368	0.349	0.313	0.294	0.276	0.256	0.237	0.206	0.178	0.155	0.134
1.0	0.494	0.480	0.467	0.433	0.408	0.383	0.340	0.320	0.300	0.277	0.254	0.218	0.186	0.159	0.137
1.2	0.579	0.562	0.544	0.509	0.464	0.420	0.393	0.365	0.337	0.310	0.282	0.234	0.198	0.164	0.135
1.4	0.653	0.634	0.614	0.566	0.528	0.490	0.436	0.401	0.366	0.334	0.301	0.246	0.204	0.164	0.131
1.6	0.714	0.694	0.675	0.620	0.577	0.534	0.473	0.433	0.393	0.354	0.314	0.250	0.203	0.159	0.124
1.8	0.764	0.746	0.727	0.665	0.620	0.574	0.502	0.458	0.414	0.368	0.322	0.250	0.196	0.151	0.116
2.0	0.808	0.790	0.772	0.705	0.658	0.610	0.528	0.479	0.430	0.378	0.325	0.246	0.188	0.142	0.106
2.2	0.843	0.826	0.810	0.743	0.692	0.641	0.551	0.496	0.442	0.385	0.328	0.241	0.180	0.134	0.100
2.4	0.873	0.858	0.842	0.776	0.722	0.669	0.572	0.512	0.452	0.391	0.330	0.236	0.173	0.126	0.092
2.6	0.896	0.876	0.866	0.805	0.750	0.694	0.591	0.526	0.460	0.395	0.330	0.230	0.166	0.117	0.085
2.8	0.914	0.900	0.886	0.830	0.772	0.714	0.607	0.536	0.466	0.397	0.329	0.224	0.158	0.108	0.078
3.0	0.928	0.914	0.901	0.850	0.791	0.732	0.621	0.546	0.470	0.398	0.325	0.218	0.150	0.100	0.071
3.25	0.938	0.926	0.914	0.866	0.808	0.750	0.638	0.557	0.476	0.397	0.318	0.208	0.140	0.092	0.063
3.5	0.949	0.938	0.928	0.882	0.826	0.769	0.654	0.568	0.481	0.396	0.311	0.198	0.130	0.083	0.055
4.0	0.970	0.963	0.956	0.915	0.860	0.806	0.688	0.590	0.492	0.394	0.297	0.178	0.110	0.066	0.039
5.0	0.980	0.975	0.970	0.943	0.894	0.845	0.725	0.610	0.496	0.380	0.265	0.145	...	...	...
6.0	0.990	0.988	0.985	0.971	0.927	0.884	0.762	0.631	0.500	0.366	0.233	0.112	...	...	...

TABLE VIII-A: SHORT AXIS

	← $k = x/p'$ →															
$\lambda q'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5	1.6
0.1	0.017	0.017	0.017	0.017	0.016	0.016	0.016	0.016	0.016	0.015	0.014	0.013	0.013	0.012	0.012	0.011
0.2	0.047	0.046	0.046	0.045	0.044	0.044	0.042	0.041	0.040	0.037	0.034	0.033	0.032	0.031	0.030	0.029
0.3	0.085	0.084	0.083	0.080	0.078	0.077	0.075	0.072	0.068	0.066	0.064	0.062	0.058	0.056	0.054	0.051
0.4	0.126	0.124	0.122	0.118	0.115	0.112	0.108	0.104	0.100	0.095	0.090	0.087	0.084	0.078	0.074	0.071
0.5	0.176	0.172	0.169	0.157	0.153	0.148	0.143	0.138	0.132	0.126	0.120	0.114	0.109	0.101	0.096	0.088
0.6	0.220	0.216	0.211	0.198	0.190	0.183	0.177	0.170	0.163	0.155	0.147	0.138	0.131	0.123	0.114	0.106
0.7	0.268	0.262	0.257	0.240	0.230	0.219	0.210	0.202	0.194	0.184	0.174	0.161	0.151	0.139	0.129	0.119
0.8	0.311	0.305	0.299	0.278	0.266	0.253	0.241	0.231	0.221	0.210	0.198	0.182	0.168	0.154	0.141	0.131
0.9	0.354	0.346	0.339	0.317	0.302	0.286	0.270	0.259	0.247	0.234	0.222	0.201	0.183	0.167	0.152	0.140
1.0	0.396	0.387	0.378	0.355	0.348	0.320	0.297	0.284	0.271	0.256	0.242	0.220	0.198	0.180	0.164	0.148
1.2	0.472	0.462	0.452	0.429	0.403	0.377	0.347	0.330	0.313	0.299	0.285	0.248	0.219	0.198	0.177	0.156
1.4	0.542	0.530	0.519	0.500	0.464	0.427	0.389	0.367	0.345	0.330	0.314	0.268	0.235	0.208	0.183	0.159
1.6	0.607	0.598	0.580	0.541	0.506	0.472	0.425	0.400	0.374	0.352	0.330	0.281	0.242	0.211	0.184	0.158
1.8	0.664	0.650	0.635	0.582	0.545	0.508	0.458	0.428	0.398	0.368	0.338	0.290	0.246	0.210	0.180	0.154
2.0	0.715	0.700	0.684	0.622	0.582	0.541	0.487	0.454	0.420	0.382	0.345	0.296	0.247	0.206	0.174	0.147
2.2	0.756	0.740	0.723	0.656	0.613	0.570	0.509	0.474	0.439	0.394	0.350	0.299	0.246	0.201	0.166	0.138
2.4	0.794	0.776	0.758	0.689	0.642	0.596	0.527	0.490	0.453	0.404	0.355	0.299	0.242	0.195	0.158	0.130
2.6	0.825	0.806	0.786	0.718	0.669	0.620	0.542	0.502	0.463	0.411	0.359	0.298	0.238	0.188	0.150	0.122
2.8	0.850	0.829	0.808	0.744	0.692	0.640	0.554	0.512	0.469	0.416	0.364	0.294	0.231	0.180	0.142	0.114
3.0	0.870	0.848	0.827	0.765	0.710	0.655	0.574	0.523	0.472	0.418	0.368	0.288	0.223	0.172	0.135	0.105
3.25	0.888	0.868	0.849	0.784	0.728	0.672	0.586	0.526	0.477	0.420	0.364	0.280	0.213	0.162	0.126	0.096
3.5	0.905	0.888	0.871	0.804	0.746	0.688	0.597	0.540	0.482	0.422	0.361	0.272	0.203	0.151	0.116	0.088
4.0	0.940	0.928	0.915	0.844	0.783	0.722	0.620	0.556	0.491	0.422	0.354	0.256	0.183	0.130	0.096	0.070
5.0	0.960	0.948	0.936	0.902	0.834	0.766	0.660	0.578	0.496	0.414	0.332	0.223	0.152	0.102	0.072	0.049
6.0	0.980	0.968	0.956	0.960	0.884	0.809	0.680	0.590	0.500	0.405	0.310	0.190	0.121	0.073	0.048	0.028

TABLE VIII-B: RATIO OF SIDES 1.5:1. LONG AXIS

	← $k = x/q'$ →															
$\lambda p'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5	1.6
0.1	0.034	0.032	0.031	0.030	0.029	0.029	0.028	0.027	0.026	0.024	0.023	0.022	0.021	0.020	0.019	0.018
0.2	0.073	0.072	0.071	0.068	0.066	0.065	0.060	0.058	0.056	0.052	0.049	0.047	0.045	0.042	0.040	0.038
0.3	0.136	0.132	0.129	0.120	0.116	0.112	0.104	0.099	0.094	0.090	0.086	0.079	0.072	0.067	0.063	0.058
0.4	0.194	0.189	0.184	0.172	0.164	0.157	0.148	0.140	0.132	0.126	0.121	0.109	0.098	0.089	0.082	0.075
0.5	0.256	0.250	0.243	0.226	0.214	0.203	0.188	0.178	0.168	0.159	0.150	0.134	0.119	0.106	0.096	0.086
0.6	0.315	0.308	0.301	0.281	0.266	0.250	0.230	0.217	0.204	0.190	0.177	0.157	0.136	0.121	0.107	0.095
0.7	0.373	0.364	0.356	0.330	0.310	0.291	0.265	0.250	0.235	0.218	0.200	0.176	0.150	0.131	0.112	0.098
0.8	0.429	0.418	0.408	0.377	0.354	0.330	0.298	0.280	0.262	0.242	0.221	0.192	0.161	0.138	0.116	0.100
0.9	0.480	0.468	0.456	0.420	0.393	0.366	0.329	0.306	0.284	0.262	0.239	0.204	0.170	0.143	0.119	0.101
1.0	0.530	0.516	0.501	0.461	0.430	0.400	0.360	0.333	0.306	0.280	0.255	0.212	0.175	0.145	0.120	0.101
1.2	0.613	0.596	0.579	0.532	0.495	0.458	0.409	0.364	0.320	0.298	0.276	0.221	0.180	0.144	0.118	0.097
1.4	0.684	0.666	0.649	0.599	0.558	0.516	0.454	0.412	0.370	0.331	0.292	0.228	0.178	0.138	0.111	0.089
1.6	0.744	0.726	0.708	0.654	0.607	0.560	0.494	0.444	0.395	0.350	0.304	0.230	0.173	0.132	0.101	0.078
1.8	0.793	0.775	0.757	0.700	0.650	0.601	0.525	0.470	0.414	0.362	0.310	0.228	0.167	0.124	0.090	0.068
2.0	0.834	0.817	0.800	0.743	0.690	0.638	0.552	0.491	0.430	0.370	0.311	0.225	0.160	0.116	0.082	0.060
2.2	0.866	0.850	0.833	0.780	0.726	0.671	0.577	0.510	0.443	0.378	0.312	0.220	0.152	0.108	0.076	0.054
2.4	0.892	0.877	0.862	0.812	0.756	0.700	0.600	0.527	0.454	0.382	0.311	0.215	0.144	0.099	0.068	0.048
2.6	0.912	0.899	0.886	0.840	0.782	0.724	0.619	0.542	0.464	0.386	0.309	0.208	0.136	0.091	0.062	0.042
2.8	0.928	0.916	0.904	0.863	0.804	0.745	0.636	0.554	0.472	0.388	0.306	0.200	0.129	0.082	0.055	0.036
3.0	0.940	0.930	0.920	0.880	0.820	0.761	0.652	0.564	0.476	0.388	0.303	0.192	0.122	0.073	0.049	0.030
3.25	0.950	0.941	0.932	0.895	0.838	0.780	0.667	0.574	0.480	0.388	0.295	0.182	0.111	0.067	...	...
3.5	0.960	0.952	0.945	0.910	0.854	0.798	0.682	0.583	0.484	0.386	0.287	0.172	0.101	0.061	...	...
4.0	0.980	0.975	0.970	0.940	0.888	0.836	0.712	0.602	0.492	0.382	0.271	0.152	0.080	0.049	...	...
5.0	0.986	0.982	0.979	0.954	0.914	0.873	0.754	0.625	0.496	0.366	0.236	...	...	...	...	...
6.0	0.995	0.992	0.988	0.968	0.939	0.910	0.795	0.648	0.500	0.350	0.200	...	...	...	...	...

TABLE VIII-B: SHORT AXIS

	← $k = x/p'$ →															
$\lambda q'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5	1.6
0.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
0.2	0.041	0.040	0.040	0.040	0.039	0.039	0.038	0.037	0.036	0.033	0.030	0.028	...	...	...	...
0.3	0.075	0.074	0.072	0.070	0.069	0.068	0.067	0.064	0.061	0.058	0.055	0.054	0.052	0.051	0.050	0.047
0.4	0.112	0.110	0.108	0.104	0.102	0.100	0.097	0.093	0.089	0.086	0.082	0.078	0.076	0.074	0.070	0.067
0.5	0.152	0.150	0.147	0.140	0.137	0.134	0.129	0.124	0.119	0.114	0.110	0.104	0.100	0.096	0.092	0.086
0.6	0.192	0.190	0.187	0.179	0.172	0.166	0.160	0.154	0.148	0.142	0.136	0.128	0.123	0.115	0.110	0.103
0.7	0.232	0.228	0.225	0.214	0.206	0.199	0.192	0.184	0.177	0.170	0.162	0.150	0.143	0.135	0.128	0.120
0.8	0.273	0.268	0.263	0.250	0.240	0.230	0.221	0.212	0.204	0.195	0.186	0.172	0.162	0.152	0.143	0.133
0.9	0.312	0.306	0.300	0.285	0.274	0.262	0.249	0.239	0.229	0.218	0.208	0.193	0.180	0.167	0.154	0.144
1.0	0.355	0.347	0.339	0.320	0.306	0.291	0.277	0.265	0.253	0.241	0.229	0.213	0.196	0.181	0.165	0.153
1.2	0.426	0.417	0.408	0.384	0.365	0.346	0.324	0.305	0.296	0.281	0.266	0.244	0.211	0.202	0.183	0.168
1.4	0.494	0.482	0.471	0.421	0.408	0.395	0.366	0.350	0.333	0.314	0.296	0.266	0.220	0.216	0.194	0.175
1.6	0.562	0.546	0.531	0.494	0.465	0.437	0.403	0.384	0.364	0.342	0.319	0.284	0.252	0.222	0.198	0.176
1.8	0.618	0.600	0.582	0.544	0.509	0.474	0.436	0.412	0.389	0.364	0.338	0.297	0.260	0.226	0.199	0.174
2.0	0.664	0.645	0.626	0.584	0.548	0.508	0.466	0.437	0.408	0.380	0.352	0.306	0.265	0.228	0.197	0.170
2.2	0.703	0.684	0.664	0.616	0.578	0.541	0.492	0.458	0.424	0.392	0.361	0.311	0.266	0.226	0.194	0.164
2.4	0.739	0.718	0.698	0.647	0.608	0.569	0.512	0.475	0.438	0.403	0.368	0.314	0.266	0.224	0.188	0.158
2.6	0.772	0.750	0.729	0.674	0.633	0.592	0.527	0.488	0.450	0.412	0.374	0.314	0.262	0.218	0.181	0.151
2.8	0.803	0.780	0.758	0.701	0.655	0.610	0.540	0.500	0.460	0.419	0.378	0.312	0.257	0.212	0.172	0.143
3.0	0.834	0.810	0.786	0.726	0.674	0.623	0.550	0.508	0.467	0.424	0.380	0.310	0.250	0.204	0.163	0.135
3.25	0.855	0.831	0.808	0.746	0.693	0.640	0.562	0.517	0.472	0.425	0.378	0.304	0.242	0.195	0.154	0.126
3.5	0.876	0.854	0.831	0.767	0.716	0.656	0.574	0.525	0.476	0.426	0.376	0.298	0.234	0.186	0.145	0.116
4.0	0.918	0.896	0.875	0.808	0.749	0.690	0.598	0.542	0.486	0.430	0.373	0.285	0.217	0.167	0.127	0.097
5.0	0.947	0.928	0.910	0.848	0.789	0.730	0.628	0.609	0.490	0.420	0.354	0.266	0.186	0.136	0.100	0.072
6.0	0.976	0.960	0.945	0.888	0.829	0.770	0.658	0.621	0.493	0.414	0.335	0.226	0.156	0.104	0.072	0.048

TABLE VIII-C: RATIO OF SIDES 2:1 LONG AXIS

	← $k = x/q'$ →															
$\lambda p'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5	1.6
0.1	0.038	0.038	0.037	0.036	0.035	0.034	0.032	0.030	0.027	0.024	0.021	0.021	0.020	...	...	...
0.2	0.088	0.087	0.086	0.081	0.080	0.080	0.072	0.068	0.064	0.060	0.056	0.053	0.050	0.046	0.042	0.040
0.3	0.160	0.156	0.151	0.141	0.135	0.129	0.118	0.112	0.106	0.100	0.094	0.086	0.077	0.070	0.062	0.057
0.4	0.224	0.218	0.213	0.200	0.189	0.178	0.165	0.155	0.145	0.136	0.126	0.112	0.099	0.088	0.078	0.070
0.5	0.293	0.286	0.280	0.260	0.244	0.227	0.208	0.195	0.182	0.169	0.156	0.134	0.116	0.100	0.088	0.076
0.6	0.359	0.350	0.340	0.316	0.296	0.276	0.248	0.232	0.215	0.198	0.180	0.150	0.128	0.109	0.094	0.080
0.7	0.418	0.407	0.396	0.366	0.342	0.318	0.286	0.264	0.243	0.222	0.200	0.164	0.138	0.114	0.096	0.080
0.8	0.475	0.462	0.450	0.414	0.382	0.351	0.320	0.294	0.268	0.244	0.219	0.176	0.144	0.117	0.096	0.079
0.9	0.526	0.514	0.502	0.462	0.430	0.398	0.352	0.322	0.292	0.263	0.234	0.186	0.148	0.118	0.094	0.076
1.0	0.576	0.562	0.548	0.507	0.471	0.435	0.382	0.348	0.314	0.280	0.246	0.192	0.149	0.118	0.092	0.072
1.2	0.660	0.650	0.639	0.581	0.540	0.500	0.432	0.390	0.348	0.307	0.264	0.196	0.148	0.113	0.085	0.064
1.4	0.725	0.710	0.694	0.646	0.602	0.557	0.478	0.427	0.376	0.325	0.274	0.196	0.142	0.104	0.076	0.055
1.6	0.778	0.762	0.747	0.700	0.653	0.606	0.520	0.459	0.398	0.342	0.277	0.194	0.136	0.094	0.066	0.047
1.8	0.819	0.806	0.792	0.748	0.698	0.649	0.554	0.485	0.416	0.348	0.279	0.188	0.128	0.084	0.056	0.040
2.0	0.853	0.842	0.831	0.790	0.738	0.685	0.585	0.508	0.432	0.356	0.280	0.182	0.118	0.075	0.049	0.036
2.2	0.878	0.870	0.862	0.825	0.771	0.717	0.611	0.528	0.444	0.361	0.278	0.174	0.109	0.068	0.042	0.030
2.4	0.902	0.896	0.889	0.854	0.800	0.744	0.635	0.544	0.454	0.365	0.276	0.165	0.099	0.062	0.036	0.024
2.6	0.922	0.916	0.910	0.878	0.824	0.770	0.656	0.560	0.463	0.368	0.272	0.156	0.089	0.054	0.030	...
2.8	0.936	0.931	0.926	0.896	0.844	0.793	0.676	0.573	0.470	0.368	0.265	0.147	0.080	0.048	0.023	...
3.0	0.948	0.943	0.938	0.910	0.862	0.815	0.695	0.586	0.476	0.366	0.257	0.137	0.070	0.041	...	...
3.25	0.956	0.952	0.948	0.918	0.875	0.832	0.712	0.597	0.482	0.363	0.246	0.127	...	...	...	...
3.5	0.964	0.961	0.958	0.925	0.888	0.850	0.730	0.610	0.489	0.362	0.236	0.117	...	...	...	...
4.0	0.980	0.979	0.978	0.940	0.912	0.885	0.765	0.634	0.502	0.358	0.214	0.097	...	...	...	...

TABLE VIII-C: SHORT AXIS

	← $k = x/p'$ →															
$\lambda q'$	0	0.2	0.4	0.6	0.7	0.8	0.9	0.95	1.0	1.05	1.1	1.2	1.3	1.4	1.5	1.6
0.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
0.2	0.036	0.035	0.035	0.034	0.034	0.034	0.033	0.033	0.033	...	...	...	...	...	...	...
0.3	0.061	0.060	0.059	0.057	0.056	0.057	0.055	0.054	0.053	0.052	0.050	0.045	0.044	0.044	0.043	0.042
0.4	0.089	0.088	0.086	0.084	0.084	0.083	0.081	0.078	0.074	0.071	0.068	0.065	0.064	0.062	0.061	0.058
0.5	0.121	0.119	0.117	0.113	0.112	0.111	0.109	0.104	0.100	0.097	0.094	0.088	0.086	0.083	0.080	0.076
0.6	0.153	0.152	0.150	0.145	0.142	0.140	0.136	0.131	0.126	0.122	0.117	0.112	0.108	0.104	0.099	0.093
0.7	0.186	0.184	0.182	0.175	0.172	0.168	0.162	0.156	0.151	0.146	0.140	0.133	0.128	0.123	0.116	0.108
0.8	0.222	0.218	0.214	0.205	0.200	0.196	0.188	0.181	0.175	0.168	0.162	0.154	0.146	0.140	0.132	0.122
0.9	0.259	0.252	0.246	0.234	0.228	0.223	0.213	0.206	0.199	0.191	0.183	0.174	0.164	0.158	0.148	0.136
1.0	0.294	0.288	0.281	0.268	0.258	0.249	0.240	0.232	0.223	0.214	0.204	0.193	0.182	0.173	0.162	0.149
1.2	0.357	0.349	0.341	0.322	0.311	0.300	0.285	0.274	0.264	0.252	0.239	0.225	0.210	0.197	0.183	0.167
1.4	0.419	0.408	0.398	0.374	0.360	0.346	0.326	0.314	0.301	0.286	0.272	0.254	0.235	0.218	0.197	0.180
1.6	0.477	0.464	0.451	0.422	0.405	0.388	0.362	0.347	0.334	0.316	0.299	0.278	0.254	0.234	0.207	0.188
1.8	0.530	0.515	0.500	0.467	0.446	0.426	0.394	0.378	0.361	0.342	0.324	0.297	0.266	0.244	0.215	0.192
2.0	0.576	0.560	0.545	0.511	0.485	0.459	0.420	0.402	0.384	0.364	0.345	0.312	0.275	0.248	0.222	0.193
2.2	0.619	0.602	0.585	0.546	0.516	0.486	0.444	0.423	0.402	0.381	0.360	0.322	0.282	0.250	0.222	0.192
2.4	0.659	0.640	0.620	0.578	0.544	0.511	0.466	0.442	0.418	0.395	0.372	0.330	0.286	0.250	0.221	0.190
2.6	0.694	0.673	0.652	0.606	0.569	0.532	0.486	0.459	0.432	0.406	0.380	0.334	0.288	0.248	0.218	0.186
2.8	0.726	0.703	0.680	0.632	0.593	0.554	0.504	0.474	0.444	0.414	0.385	0.334	0.288	0.244	0.214	0.180
3.0	0.754	0.728	0.703	0.653	0.613	0.573	0.520	0.487	0.454	0.420	0.387	0.332	0.285	0.240	0.207	0.173
3.25	0.780	0.754	0.728	0.676	0.633	0.590	0.533	0.497	0.461	0.424	0.388	0.329	0.278	0.234	0.198	0.164
3.5	0.804	0.779	0.754	0.698	0.652	0.606	0.546	0.507	0.468	0.429	0.390	0.326	0.271	0.228	0.190	0.154
4.0	0.853	0.828	0.804	0.743	0.692	0.640	0.571	0.526	0.482	0.437	0.393	0.321	0.258	0.216	0.172	0.134
5.0	0.900	0.878	0.856	0.792	0.735	0.678	0.596	0.543	0.490	0.439	0.378	0.293	0.249	0.184	0.140	0.104
6.0	0.948	0.928	0.907	0.840	0.778	0.716	0.620	0.559	0.498	0.430	0.362	0.265	0.200	0.151	0.109	0.074

TABLE IX: CALCULATIONS FOR ISODOSE CHART. SHORT AXIS. FIELD 12 × 8 cm.
F.S.D. = 50 cm. h.v.l. = 2.0 mm. Cu. $q = 6$. $p = 4$

Depth (cm.)	P	M	$\chi\frac{f+d}{f}$	$\lambda\frac{f+d}{f}q=\lambda q'$	$k = 0$ I_0	S_0	D_0
0	100.0	36.2	0.385	2.310	0.723	26.1	126.1
1	80.6	54.5	0.426	2.556	0.765	41.7	122.3
3	52.5	65.0	0.370	2.220	0.707	46.0	98.5
5	34.3	65.0	0.342	2.052	0.674	43.7	78.0
10	11.9	49.6	0.288	1.728	0.598	29.7	41.6

Depth (cm.)	$k = 0.6 = x/p'$ $I_{0.6}$	$S_{0.6}$	$D_{0.6}$	$x_{0.6}$	$k = 0.9 = x/p'$ $I_{0.9}$	$S_{0.9}$	$O_{0.9}$	$x_{0.9}$
0	0.635	23.0	123.0	2.40	0.503	18.2	118.2	3.60
1	0.668	36.4	117.0	2.44	0.524	28.6	109.2	3.66
3	0.619	40.2	92.7	2.54	0.494	32.1	84.6	3.82
5	0.592	38.5	72.8	2.64	0.472	30.7	65.0	3.96
10	0.528	26.2	38.1	2.88	0.424	21.0	32.9	4.32

to the various k's (as described above) will take the place of the lines $x = 1$, etc.

DOSES IN RECTANGULAR FIELDS

For rectangular fields the computation of the scatter is rather more complicated, since this depends not only on the size of the field and the position of the point in it, but also on the ratio of the lengths of the sides of the rectangle. Meredith and Neary divided any field into triangles and evaluated the scatter integrals for the triangles in terms of one angle and the length of the base. Thus, a general point in a rectangle calls for the calculation and addition of eight figures, and even a point on one of the major axes needs four evaluations. A considerable amount of numerical work is thus involved.

Mitchell (7) considered that for any particular degree of elongation of the rectangle the triangles can be combined. He therefore set up a series of tables for different ratios of long to short side; with his permission, these are reproduced in Table VII for square fields, and in Table VIII for fields with long to short side ratios 1.25 : 1, 1.5 : 1, and 2 : 1. For the intermediate ratios found in practice, the table for the nearest ratio is satisfactory. The table for the 2 : 1 ratio can be used adequately up to 2.5 : 1; beyond this, it is unlikely that there will be much need for isodose charts.

The constants M and $\lambda\frac{f+d}{f}$ are the same as for the circular fields, and the primary radiation is the same. The following replacements, however, must be made in the constants illustrated in Figure 1:

Instead of a = radius of field on surface
use p = half length of short edge of rectangle
q = half length of long edge

Instead of $r = a\frac{f+d}{f}$ and $k = x/r$

use $p' = p\frac{f+d}{f}$ and

$q' = q\frac{f+d}{f}$ and

$k = x/p'$ or x/q'

Instead of $\lambda r = \lambda\frac{f+d}{f}a$

use $\lambda p' = \lambda\frac{f+d}{f}p$ and

$\lambda q' = \lambda\frac{f+d}{f}q$

The tables are in two parts (except for the square); the upper for the isodose chart through the long axis, the lower for the short. In each case, x is the distance from the center along the axis in question and at the depth under consideration. The dose at a particular point on either axis is found in the same way as for circular fields. If the point is on the short axis, $k = x/p'$ and the scatter function is found under $\lambda\frac{f+d}{f}q = \lambda q'$. For ex-

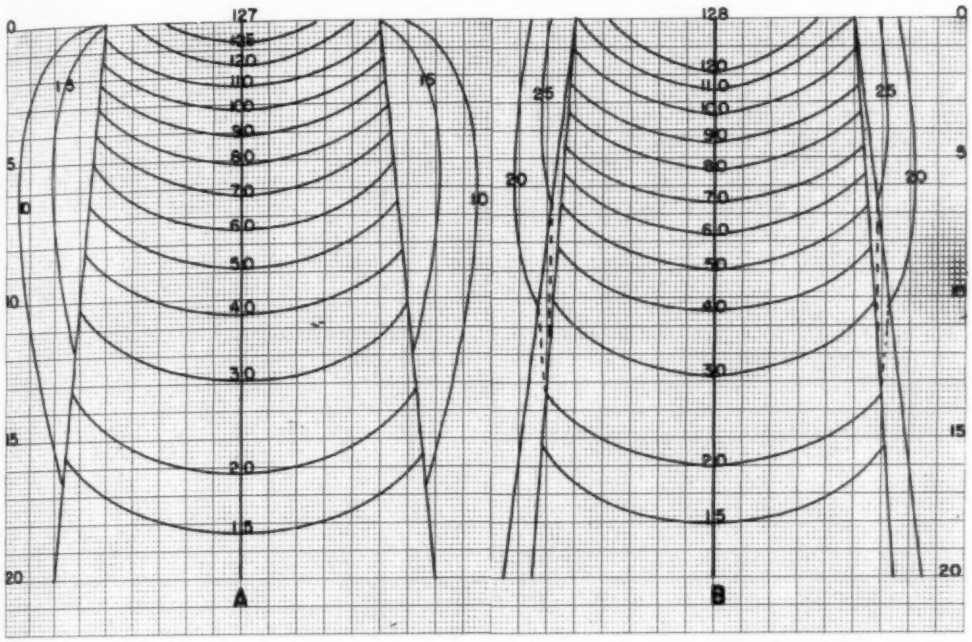

Fig. 5. Isodose charts for square field 10 × 10 cm., 50 cm. F.S.D., h.v.l. 2.0 mm. Cu. A. Calculated. B. Measured at Columbia-Presbyterian Medical Center. (The double line at the edge indicates penumbra uncertainty.)

ample, find the dose at a point 8 cm. deep and 4 cm. from the center of the field on the short axis of a 10 × 15-cm. rectangle, using a focal-skin distance of 70 cm. and a h.v.l. of 2.0 mm. Cu.

$$p = 5;\ q = 7.5 \qquad p' = 5 \times (78/70) = 5.6$$

$$x = 4 \qquad k = x/p' = 4/5.6 = 0.715$$

$$\lambda\frac{f+d}{f} = 0.308 \text{ (Table III)}$$

$$\lambda\frac{f+d}{f}\,q = \lambda q' = 2.3$$

$I_r = 0.59$ (Table VIII)
$M = 59.2$ (Table IV) $\qquad P = 19.6$ (Table I)

$S = 34.9 \qquad D = 54.5$ r per 100 r in air at the position of the center of the field

For calculations of isodose-chart data, the second method described for circular fields is preferable. The interpolation necessary in the tables may be minimized by plotting the data as I_r against $\lambda\frac{f+d}{f}\,p$ $(= \lambda p')$ or $\lambda\frac{f+d}{f}\,q\,(= \lambda q')$ for the various k's to be used in the particular problem. Table IX gives a part of the calculations for the isodose chart through the short axis of a 12 × 8-cm. field (ratio 15:1).

In Figure 5 are shown a calculated isodose chart for a 10 × 10-cm. square field, 50 cm. F.S.D., h.v.l. 2.0 mm. Cu and one obtained for the same field by ionization chamber measurement at the Columbia-Presbyterian Medical Center. The double line at the edge of the beam indicates penumbra uncertainty.

Figure 6 presents similar calculated and measured charts for the short axis of a 10 × 8-cm. rectangular field, 50 cm. F.S.D., h.v.l. 4.0 mm. Cu.

DISCUSSION

It is evident that the results obtained can never be more accurate than the data on which they are based. In this case, the critical consideration is how well the scattered radiation is described by the

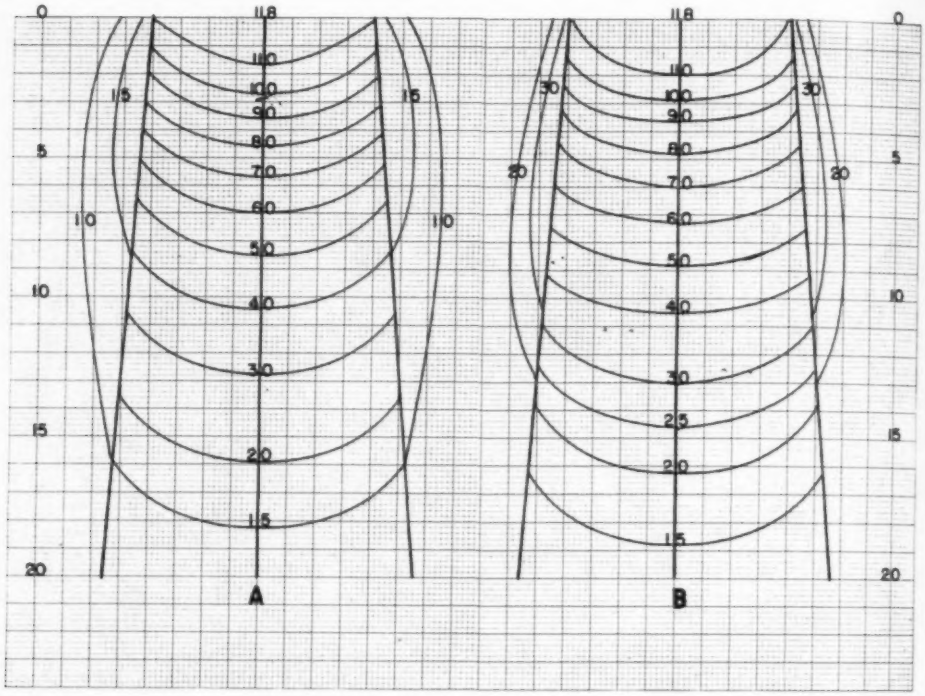

Fig. 6. Isodose charts through short axis of rectangular field, 10 × 8 cm., 50 cm. T.S.D., h.v.l. 4.0 mm. Cu. A. Calculated. B. Measured at Columbia-Presbyterian Medical Center.

formula employed. In determining the constants, scatter values were used for fields of 50, 100, 200, and 400 sq. cm. Accordingly, for testing, central-axis depth doses were calculated for 25, 150, and 300 sq. cm., namely, for a field smaller than any used in the derivations, and two intermediate unused ones. In all cases, calculations were made for h.v.l.'s 1.0, 2.0, 4.0, 6.0, and 8.0 mm. Cu and for 50 cm. and either 70 or 80 cm. F.S.D. For the larger fields, the differences between calculated values and those from the tables never exceeded ±4 per cent, except beyond the 15 cm. depth, where in a few instances it was 6 to 8 per cent; there was no systematic deviation. For the 25-sq. cm. field, calculated values were always less than tabulated ones, but for depths up to 10 cm. the difference was seldom more than 4 per cent. For greater depths, differences up to 10 per cent were fairly frequent. Here the entire dose is so small that differences of this magnitude offer no real difficulty.

The method here described results in an isodose chart with a sharp break at the geometric edge of the beam. This would be expected if a true point source and ideal collimating system were used; and has indeed been found by various investigators for particular diaphragm systems. If, however, a certain installation is known to give a beam with a considerable penumbra, this region should be treated as one of uncertainty. Possibly curves through it should be dotted, as indicated in Figure 5B.

SUMMARY

The method of Meredith and Neary for calculating the dose of radiation at any point within the body has been adapted to the depth-dose tables most widely used in the United States. No details of the theory are given; for these, the reader is referred to the original papers.

Values of the constants involved and values of the integrals for circular and rectangular fields are tabulated, the latter being adapted from the tables developed by R. G. Mitchell.

Step-by-step outlines are given of the method for finding dose at a particular point, and for computing data for isodose charts.

Examples of calculated isodose charts are given, and compared with those obtained by ionization measurements in a water phantom.

The accuracy with which the method represents the basic depth-dose data is discussed.

ACKNOWLEDGMENTS: The authors wish to express their thanks to Dr. R. G. Mitchell for his generous permission to reproduce his tables. They are grateful to Dr. Harold E. Johns and to Charles C Thomas, for permission to reproduce a published isodose chart, and to Miss Ginette Jacob for the measured isodose charts from the Presbyterian Hospital. They also desire to express their indebtedness to the American Cancer Society for its liberal support of the project.

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SUMARIO

Cálculo de las Dosis Tejido y Datos para la Elaboración de Gráficas de Isodosis, Usando Tablas Normalizadas de Dosis a Profundidad

El método de Meredith y Neary para calcular la dosis de irradiación llevada a cualquier punto dentro del cuerpo ha sido adaptado a las tablas de dosis a profundidad más usadas en los Estados Unidos. No se ofrecen pormenores de la teoría, que encontrará el lector en los trabajos primitivos.

Se tabulan los valores de las constantes comprendidas y los valores de los integrales para campos, circulares y rectangulares, adaptándose los últimos de las tablas elaboradas por R. G. Mitchell.

Se delinea paso a paso el método para determinar la dosis en un punto dado y para computar los datos destinados a gráficas de isodosis.

Se ofrecen ejemplos de gráficas de isodosis calculadas, comparándose con las obtenidas con mediciones de la yonización en un fantasma de agua.

Discútese la exactitiud con que el método representa los datos fundamentales de la dosis a profundidad.

Gas Embolism

Roentgenologic Considerations, Including the Experimental Use of Carbon Dioxide as an Intracardiac Contrast Material[1]

HERBERT M. STAUFFER, M.D., THOMAS M. DURANT, M.D., and M. J. OPPENHEIMER, M.D.

THE USE OF gas injection for contrast in clinical diagnostic roentgenology is increasing. The danger of venous or arterial gas embolism is always inherent in such diagnostic procedures as well as in therapeutic procedures in which entry of air into the circulation may occur.

The hazards of gas embolism are particularly present in the direct translumbar injection of air or oxygen into the perirenal region, and enthusiasm for the procedure is therefore limited in many clinics. Recently, injection of air for visualization of retroperitoneal structures has been commonly carried out by the safer presacral route.

Deliberate introduction of air or oxygen by the presacral route into the mediastinum is now being widely advocated for diagnostic purposes. Pneumoperitoneum and pneumothorax have long been employed in diagnostic roentgenology; insufflation of the urinary bladder and many of the larger joints has also been performed. Angiocardiography involves a potential hazard because of possible accidental venous air embolism.

The accidental occurrence of air embolism is well known in other clinical situations, particularly in surgical procedures involving the veins of the neck or the dural sinuses, performed with the patient in a sitting position, in uterine curettage, and during delivery of patients with placenta previa. Serious sequelae following accidental entrance of air into intravenous apparatus are rare.

The greatest practical hazard probably lies in the practice of obstetrics and gynecology, since the uterine sinuses are the veins into which air may most readily enter. A number of deaths from air embolism have been reported, for example, as a result of vaginal insufflation for *Trichomonas* infestation either during pregnancy or in non-pregnant women near the time of menstruation (1).

This problem is currently of additional interest because of the possibility of gas embolism in connection with explosive decompression at high altitudes, in aviation accidents, as for instance rupture of a sealed pressurized cabin (2, 3).

Differentiation of Pulmonary (Venous) and Arterial Air Embolism: In pulmonary (venous) air embolism, the air enters one of the systemic veins and produces its effect by an air "trap" in the outflow tract of the right ventricle and main pulmonary artery and, when the patient is supine, by blockade of the small peripheral pulmonary arteries. This requires fairly large amounts of air.

In arterial embolism, the air enters the pulmonary venous channels and is carried thence to the superiorly located systemic arteries. In this fashion, very small quantities of air may produce serious blockade of one or more of the coronary or cerebral vessels.

The two forms of embolism present clinical pictures entirely different from each other. In venous embolism, the air in the right ventricle produces a loud, churning sound which may be audible without the stethoscope. This has been termed a "millwheel" murmur. If the patient is in such a position that an air trap develops in the right ventricle, the venous pressure rises and cyanosis ensues; the systemic blood pressure falls, the pulse becomes rapid and thready,

[1] From the Departments of Radiology, Medicine and Physiology, Temple University School of Medicine and Hospital. Supported in part by United States Public Health Service grant No. H-1883. Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

and syncope develops as a result of cerebral ischemia.

In arterial embolism, when the head is higher than the level of the aortic arch, air enters the cerebral circulation and causes such neurological manifestations as aphasia, blindness, and hemiplegia. Air may be observed in the retinal vessels on ophthalmoscopic examination, and a marbled appearance of the skin may indicate its presence in superficial, cutaneous vessels. Myocardial infarction has been demonstrated electrocardiographically, and blockade of the coronary arteries by air has been shown in postmortem examinations.

Cases have been reported in which both types of embolism were observed in the same individual; air entering the systemic veins produced manifestations of both pulmonary and arterial air embolism. In 2 such cases (4, 5) an interatrial septal defect was found at autopsy. Arterial air embolism caused by entrance of air into the systemic veins is referred to as "paradoxical air embolism."

Experimental Studies on Mechanisms in Venous Air Embolism: Experimental studies in dogs, including biplane roentgenography (6, 7), have demonstrated that the fundamental causes of serious circulatory disturbances in venous air embolism are both mechanical and physiological. In right decubitus or the supine position, an air trap develops in the outflow tract of the right ventricle and acts as an effective circulatory block. The pressure in the pulmonary artery beyond this trap rises, indicating a further block in the peripheral pulmonary circulation.

The immediate, primary rise in pulmonary arterial pressure is followed by a decline and then a secondary rise. Neurogenic pulmonary arterial spasm from mechanical stimulation by air bubbles, local anoxia beyond the air block, or further delivery of air increments from the ventricle may account for this secondary increase.

The systemic blood pressure falls immediately following intravenous air injection, with accompanying bradycardia and biphasic respiratory disturbances. This fall in systemic blood pressure is explained by decreased inflow into the left heart because of mechanical blockade in the pulmonary vessels. Pressoreceptors in the heart and lungs, described by Aviado (8), and veratridine reflexes from the lesser circulation, studied by von Bezold (9), may account for the hypotension and alternating apnea and hyperpnea which are observed. The low systemic pressure also contributes to the hyperpnea.

Localized right ventricular ischemia occurs. The coronary pressure gradient is markedly reduced, since coronary arterial inflow pressure is low and the pressure at the coronary venous outflow into the right heart is elevated. At the same time, right ventricular work is increased.

Body Position in Relation to Venous Air Embolism: The mortality of venous air embolism in dogs was dramatically reduced by placing the animal in left lateral decubitus (6, 7). This position provides for continuity of blood flow from the cavae to the right ventricular outflow tract, since in this position the pulmonary artery is dependent. Gas, because of its buoyancy, rises away from the outflow tract.

Roentgenographic evidence of the air block occurring in the pulmonary artery as a result of accidental air embolism during an angiocardiographic procedure has been obtained (7). Injection of the contrast material was carried out through a cervical vein, since adequate peripheral veins in the arms were not available. The patient was in the sitting position. When the saline-containing syringe was disconnected to permit attachment of the syringe of radiopaque contrast solution, a sucking sound was audible. The injection of the contrast material was completed uneventfully and subsequently the patient was able to walk across the room without difficulty. After lying down for a brief period, he became nauseated, sat up, then collapsed, and was unresponsive for about two minutes, during which

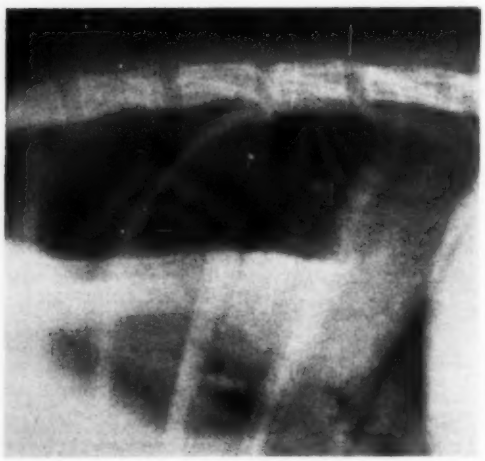

Fig. 1. Roentgenogram of dog's heart following intravenous air injection. Note tricuspid ring crossing air obliquely above fluid level.

he exhibited mild generalized convulsive movements, stertorous breathing, and marked bradycardia. Complete recovery ensued rapidly, and it was thought that the reaction was attributable to the iodine-containing contrast material. When the films were processed, however, a large air bubble was disclosed in the pulmonary artery and its left main branch; this had obviously caused a marked diminution in the blood flow to the left lung while the patient was in the upright position and was responsible for the transient symptoms subsequently observed.

A somewhat similar accident has been reported in the French literature (10). In this instance, a gas pressure apparatus employed for the injection of the radiopaque material for angiocardiography was incorrectly connected so that a quantity of oxygen was rapidly injected intravenously. The authors of the report attribute the recovery of the patient to the fact that the head was immediately lowered; in this position, the continuity of blood flow through the right ventricle into the pulmonary artery is maintained.

Safety of Carbon Dioxide as an Intracardiac Contrast Medium Demonstrated Experimentally in Dogs by Cinefluorography: In experimental air embolism studies, roentgenograms frequently afforded excellent demonstrations of the internal anatomy of the dog's heart. In the supine position, with the x-ray beam horizontal, the tricuspid ring and pulmonary valve were shown (Fig. 1). This type of angiocardiography seemed to have possible clinical application, provided a safe gas could be found. Carbon dioxide was selected for testing, since it is approximately twenty times as soluble in serum as air or oxygen. It has been shown by experiments on anesthetized dogs that carbon dioxide rapidly injected intravenously is well tolerated in large doses, and repeated injections in the same animal have produced no evident ill effects (11). Injection of air in similar quantities (7.5 c.c. per kilo) resulted in 100 per cent mortality in animals in the right decubitus position. Numerous comparative studies have been performed. Carbon dioxide was found to cause only a brief drop in systemic arterial pressure and a rise in pulmonary artery pressure. Air and oxygen are almost equally hazardous and, when injected intravenously, produce prolonged blood pressure and respiratory effects in anesthetized animals, frequently with fatal termination.

When carbon dioxide (7.5 c.c. per kg.) is given intravenously, the average change in whole blood carbon dioxide content is a 5 to 10 volume per cent increase; the change in oxygen is a 1 to 2 volume per cent decrease. Both these effects are of extremely brief duration, reaching a maximum within fifteen to thirty seconds and disappearing in one or two minutes. Under these circumstances the blood *p*H actually changes hardly at all.

Direct injection of carbon dioxide into the left ventricle or root of the aorta has also been carried out frequently, in the anesthetized dog, without apparent ill effects, in contrast to the regularly fatal outcome when air or oxygen is similarly employed (Fig. 2). Moore and Braselton (12, 13) had previously reported that carbon dioxide was well tolerated on injection into the intrapulmonary veins in

cats, while air injection under similar conditions invariably caused a typical coronary death. In our experience, a residual bubble has been consistently observed following the prompt disappearance of the bulk of the carbon dioxide injected into the left ventricular cavity. since the valve structures are incompetent for gas, permitting its flow back and forth through the valves. However, visualization of the intracardiac structures by this means is free of the difficulties of layering, irregular streaming, and dilution which impair the value of water-soluble

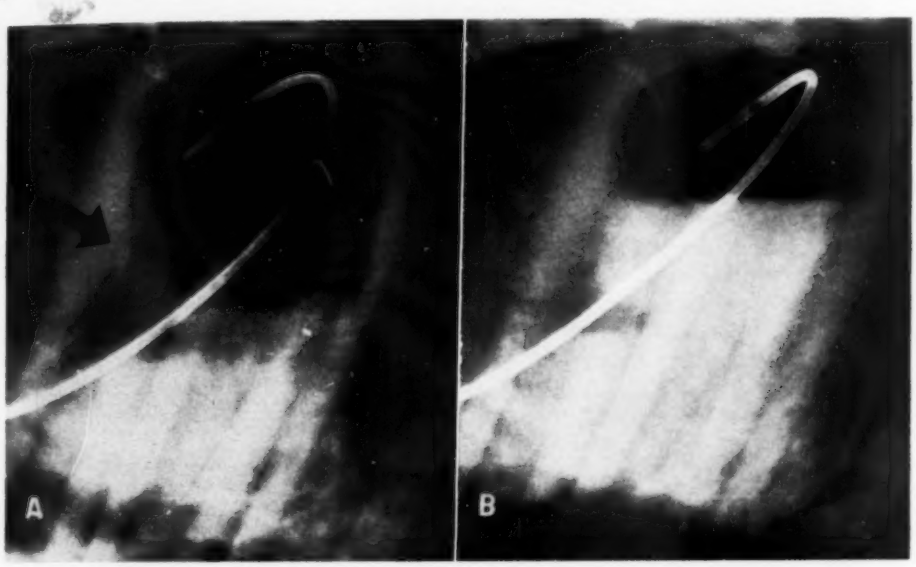

Fig. 2. Injection of carbon dioxide into left ventricle of dog *via* aortic catheter. A. Roentgenogram immediately after injection. The aortic valve cusp is indicated by the arrow. B. Three seconds after injection. Much of the gas is already dissipated.

Analysis of samples of this bubble obtained *via* catheter show that it is chiefly oxygen which has diffused from the arterial blood into the injected carbon dioxide. This bubble, a potential source of an arterial gas embolus, must be considered in the application of left heart carbon dioxide injection to clinical problems.

Cinefluorography was carried out with the Philips image amplifier employing low x-ray intensity. Sixteen-millimeter motion picture film was used, with exposures at the rate of 64 frames per second (14, 15). These studies have demonstrated the possibilities of carbon dioxide for visualization of the valve structures of the heart and valvular lesions, as well as the investigation of cardiac dynamics. Admittedly, the procedure is unphysiologic as far as cardiac mechanics are concerned, opaque contrast substances for angiocardiography (16).

The results of these experiments suggest also that development of a safe technic for selective carbon dioxide angiocardiography in the human subject may well be possible; for example, visualization of a localized area such as the pulmonary conus, the pulmonary valve, and pulmonary artery. Rapid intravenous injection of carbon dioxide (7.5 c.c./kg.) in 2 infants was well tolerated in the supine position, with only transient apnea. In one the injection was repeated within a few minutes with no difficulty. Radiographs showed the right heart chambers to be briefly outlined by gas (Fig. 3).

These studies have provided dramatic demonstration of the clinical advantages of employing for diagnostic studies a

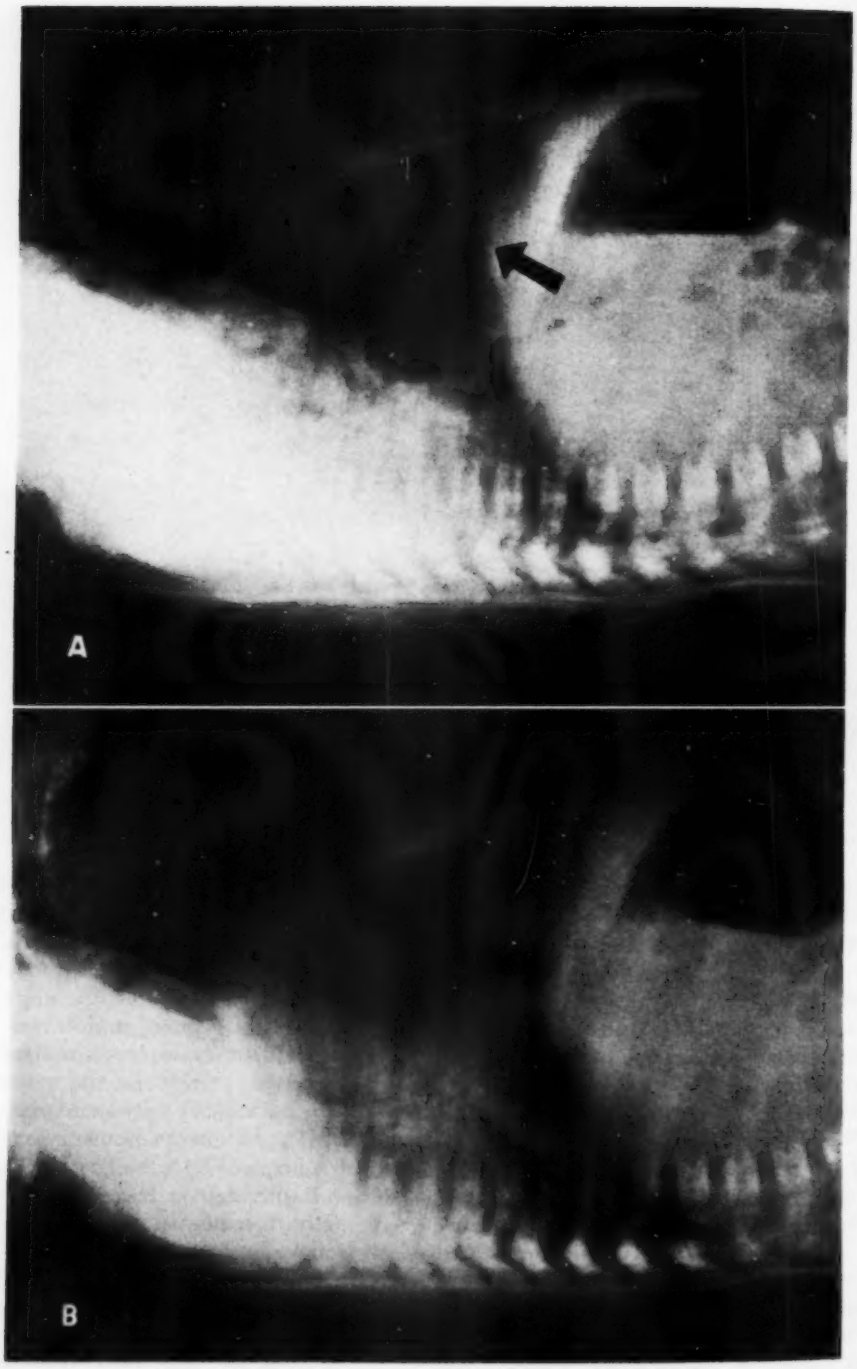

Fig. 3. Roentgenograms of infant after intravenous injection of carbon dioxide (7.5 c.c./kg.). A. Right atrium and right ventricle filled with gas immediately after injection. Tricuspid ring (arrow). B. Ten seconds after injection. Fluid level and small residual bubble in right ventricle.

rapidly soluble gas such as carbon dioxide wherever possible.

Practical Clinical Considerations: Rubin (17) in 1919 introduced the use of carbon dioxide for pneumoperitoneum by tubal insufflation, emphasizing, in a subsequent report, the advantages of rapid absorption of this gas from the peritoneal cavity. No mention was made, however, of the safety of the procedure in case of accidental introduction of gas into the systemic veins.

Teschendorf (18) recognized the importance of a readily soluble gas for use in diagnostic roentgenology and in 1951 reported his long experience with nitrous oxide. He emphasized the advantages of this gas in eliminating the hazard of gas embolism. Nitrous oxide and carbon dioxide have similar solubility coefficients in serum at body temperature, each being approximately twenty times as soluble as air or oxygen.

The results of clinical and experimental studies suggest the following recommendations for clinical practice:

1. A readily soluble gas should be used wherever possible for diagnostic or therapeutic insufflation. Carbon dioxide would seem to be preferable, although nitrous oxide may be equally satisfactory.
2. When air embolism is suspected, the patient should be immediately placed in left decubitus with the head dependent.
3. Artificial respiration should be instituted at once.
4. If other measures fail, aspiration of air from the right atrium may be attempted.

SUMMARY

The injection of gas as a contrast material in clinical diagnostic roentgenology involves hazards of venous and arterial gas embolism due to the entry of air into the circulation. The adverse physiologic effects of venous air embolism result from air trap in the outflow tract of the right ventricle and pulmonary artery and from blockade of the small peripheral pulmonary vessels. In an emergency, elimination of the air trap by placing the patient in the left decubitus position may be lifesaving. In arterial embolism, the air enters the pulmonary venous channels and is carried to the superiorly located systemic arteries. In this fashion, very small amounts of air may produce serious blockade of one or more of the coronary or cerebral vessels.

The possibilities of carbon dioxide as a contrast medium for angiocardiography were demonstrated in cinefluorographic studies. Rapid intravenous injection of large amounts of this gas (7.5 c.c./kg.) in dogs produced only minor, transient physiologic alterations. Two infants tolerated similar doses well.

This study indicates that use of a soluble gas, such as carbon dioxide, for insufflation in diagnostic roentgenology should eliminate the hazard of gas embolism.

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ADDENDUM

Since this paper was submitted, an important pertinent contribution has been made by C. L. Ransom, R. R. Landis, and R. McClelland (Air Embolism and Cardiac Arrest Following Presacral Air Injection, Mid-Atlantic Section, American Urological Association, Hot Springs, Va., April 19–21, 1956). Three hundred urologists, replying to a questionnaire, reported 53 fatalities with injection of air or oxygen (21 presacral and 32 flank injections) in a total of 8,000 patients injected.

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SUMARIO

Embolia Gaseosa. Algunas Consideraciones Diagnósticas Comprendiendo el Empleo Experimental de Bióxido de Carbono como Substancia Intracardíaca de Contraste

La inyección de gas como substancia de contraste entraña riesgos de embolia gaseosa venosa y arterial debida a la entrada de aire en la circulación. Los adversos efectos fisiológicos de la aeroembolia venosa dimanan del atrapamiento de aire en el trayecto de salida del ventrículo derecho y la arteria pulmonar y del bloqueo de los pequeños vasos pulmonares periféricos. En un apuro, la eliminación del aire atrapado colocando al enfermo en la posición de decúbito izquierdo puede salvar la vida. En la embolia arterial, el aire penetra en los conductos venosos del pulmón y es conducido a las arterias situadas más arriba en el organismo. En esa forma, pequeñísimas cantidades de aire pueden producir intensa oclusión de uno o más de los vasos coronarios o cerebrales.

Estudios experimentales en perros demostraron que las causas fundamentales de los trastornos circulatorios en la aeroembolia venosa son tanto mecánicos como fisiológicos. También se demostró experimentalmente que la rápida inyección intravenosa de grandes cantidades (7.5 c.c./kg.) de bióxido de carbono no producían más que pequeñas y pasajeras alteraciones fisiológicas. Dos lactantes toleraron bien dosis semejantes. Las posibilidades de este gas como medio de contraste para la angiocardiografía quedaron demostradas en estudios cinefluorográficos.

Indica este estudio que el uso de un gas soluble, tal como el bióxido de carbono, para insuflación en la roentgenología de diagnóstico debe eliminar el riesgo de la embolia gaseosa.

The Roentgen Manifestations of Pulmonary Hypertension in Congenital Heart Disease[1]

THEODORE E. KEATS, M.D., VAN ALLEN KREIS, M.D., and ELLEN SIMPSON, M.D.

INCREASING EXPERIENCE in diagnosis of congenital heart disease has directed attention to variants of the more common anomalies. This is particularly true of those congenital lesions producing left-to-right shunts with associated pulmonary hypertension. At present, cardiac catheterization is the only method by which pulmonary hypertension can be quantitatively demonstrated.

Recent papers by British investigators have suggested roentgen criteria which are useful in recognizing pulmonary hypertension in mitral valvular disease (1–5). No reports have yet appeared, however, concerning the roentgen manifestations of pulmonary hypertension in congenital heart disease. The purpose of the study to be presented here was to determine whether the roentgen criteria established for pulmonary hypertension in acquired cardiac disease can be applied also to congenital lesions.

REVIEW OF LITERATURE

Attinger (6) in 1948 called attention to the loss of normal pulmonary aeration as a means of distinguishing overfilling of the lesser circulation as a result of passive congestion from that due to pulmonary hypertension. This loss of aeration reduces demarcation of vessel outline in the roentgenogram.

Good and Dry (7) described enlargement of the pulmonary arteries and of the right ventricle as signs of pulmonary hypertension regardless of the cause. Pulmonary artery enlargement in congenital heart disease was reported by Dotter and Steinberg (8) and by Miller (9). Dotter and Steinberg also pointed out that the earliest angiographic change in chronic pulmonary hypertension was elongation of the pulmonary artery.

Reliable criteria have recently been established for detection of pulmonary hypertension in mitral valvular disease on the basis of routine roentgenograms (1–5). Using these signs, Carmichael *et al.* (3) were able not only to detect the presence of pulmonary hypertension but also to correlate the magnitude of the changes with the degree of hypertension. The criteria employed were enlargement of the heart, enlargement of the right ventricle, prominence of the main pulmonary artery, prominence of the perihilar vessels, disproportion between the size of the enlarged central pulmonary arteries and narrowed peripheral pulmonary arteries, tortuosity of peripheral pulmonary arteries, and the presence of fine horizontal lines at the periphery of the lungs near the costophrenic angle ("Kerley's lines").

Narrowing of the peripheral pulmonary arteries in pulmonary hypertension caused by congenital heart disease has been demonstrated in physiologic and histologic studies (11); it has not, however, been described roentgenographically. According to Swan *et al.* (11), moderate or severe pulmonary hypertension (mean pulmonary artery pressure greater than 50 mm. Hg) is always associated with an increase in pulmonary vascular resistance, apparently as a result of arteriolar and terminal arterial constriction. Presumably, it is this arterial constriction which produces the narrowing of pulmonary arteries seen in the roentgenogram.

The fine horizontal lines at the periphery of the lungs near the costophrenic angle ("Kerley's lines") were attributed to engorged peripheral lymphatics or interstitial

[1] From the Department of Radiology and the Vascular Research Laboratory of the University of California School of Medicine, San Francisco, Calif. Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

TABLE 1: FINDINGS IN 36 CASES OF CONGENITAL HEART DISEASE WITH PULMONARY HYPERTENSION IN ORDER OF INCREASING PULMONARY ARTERY PRESSURE

	Age	Diagnosis*	Systemic Pulmonary Artery Pressure (mm. Hg)	Cardiac Enlargement	Right Ventricle Enlargement	Pulmonary Artery Size	Hilar Vessel Enlargement	Pulmonary Vessel Disparity	Kerley's Lines	Vessel Tortuosity	Cyanosis	Polycythemia	Pulmonary Venous Enlargement
S.W.	15	ASD	32	+	+	+	+	0	0	0	0	0	+
G.P.	14	VSD	40	+	++	++	+++	0	+	0	0	0	0
H.C.	18	VSD	40	++	+	0	+	0	0	0	0	0	+
D.J.	7	VSD	45	++	0	0	+	0	0	0	0	0	0
B.M.	8	VSD	45	++	++	+	+	0	0	0	0	0	0
C.S.	4	VSD	45	+++	+	++	+++	++	0	0	0	0	+
G.G.	7	ASD	48	0	0	+	+	+	0	0	0	0	0
J.B.	6	VSD	50	+++	0	+	+	0	0	0	0	0	0
M.S.	45	ASD	55	+	+	++	+++	++	0	+	0	+	+
V.S.	9	VSD	55	++	++	+	+	+	0	0	+	0	+
P.K.	25	VSD	57	+++	++	++	++	0	+	0	0	0	+
W.S.	12	PDA	60	+	+	+	+	+	0	0	0	0	0
D.A.	24	VSD	60	0	++	++	+	+	0	0	0	0	+
M.T.	44	ASD	64	+++	+++	+++	+++	+++	0	+	+	0	+
M.B.	39	VSD	65	+	++	++	++	+++	0	0	+	+	0
S.S.	8	VSD	65	++	++	++	+	0	0	0	0	0	0
E.H.	13	VSD	72	+++	+++	+++	+++	++	0	+	0	0	+
J.L.	20	VSD	72	+++	+	+++	+++	+++	0	+	0	0	+
M.D.	25	PDA	73	+++	++	+++	+++	+	0	+	0	0	+
M.L.	40	ASD	77	0	+	+++	+++	+++	0	0	0	0	+
G.J.	8	?SD	80	++	+	+++	++	+	+	+	0	+	0
C.B.	3	ASD	82	+++	++	+	+++	+++	0	0	0	0	0
J.M.	6	VSD	83	++	++	+	+	0	+	+	0	0	+
S.D.	7	VSD	90	+	+++	++	++	0	0	0	0	0	+
S.G.	16	VSD	95	++	+	0	++	0	0	0	+	0	0
R.B.	6	VSD	95	+	0	+	0	+	0	0	+	+	+
G.S.	34	VSD	101	++	++	+++	+++	+++	0	0	+	+	+
J.C.	39	ASD	102	0	+	++	+++	++	0	0	+	+	0
B.S.	18	VSD	102	++	++	++	++	0	+	0	0	0	+
L.P.	30	VSD	102	+	0	+++	+	0	0	+	+	+	+
J.B.	30	PDA	103	++	++	++	++	+++	0	0	+	+	+
B.R.	12	VSD	105	0	+	+++	++	++	0	+	0	+	0
G.P.	30	PDA	109	++	++	+++	++	++	0	0	+	+	0
R.L.	42	ASD	110	+	+	+++	+++	+++	0	0	+	+	+
D.S.	6	PDA	127	+	0	+++	++	+	0	0	+	+	+
D.O.	15	VSD	130	0	+	+	+	+	0	0	+	+	+

* ASD. Atrial septal defect. VSD. Ventricular septal defect. PDA. Patent ductus arteriosus.

edema by Kerley (13) and Levin (16) and to hemosiderin adjacent to and within the interlobular septa or fluid in the interlobular septa by Fleischner (12). The nature of these lines (Fig. 1) has not yet been determined with certainty.

METHOD

The case records and chest roentgenograms of 36 patients with congenital heart disease and proved pulmonary hypertension, demonstrated by cardiac catheterization, were reviewed. The group was composed of 16 males and 20 females, ranging in age from three to forty-five years. These patients were studied by physicians at the University of California Vascular Research Laboratory between July 1951 and January 1955. Catheter pressures were measured by strain gauge manometer. Pulmonary hypertension was defined as systolic pulmonary artery pressure greater than 30 mm. Hg. Twenty-two patients had ventricular septal defects, 8 atrial septal defects, 5 patent ductus arteriosus, and 1 an unclassified septal defect. Roentgenograms of 15 patients with congenital heart disease of the same types but with proved normal pulmonary artery pressures were reviewed concurrently to prevent overreading. Clinical records were evaluated for the presence or absence of cyanosis and polycythemia.

The plain chest films of each patient were reviewed without knowledge of the clinical or catheterization findings and evaluated for the presence and degree of cardiac enlargement, right ventricular enlargement, enlargement of the main pulmonary artery, presence or absence of tortuosity of the peripheral arteries, relative size of the pulmonary veins, the presence and degree of relative narrowing of the peripheral arteries, and the presence or absence of Kerley's lines.

RESULTS

The observations made on the individual patients are presented in Table I and summarized in Table II.

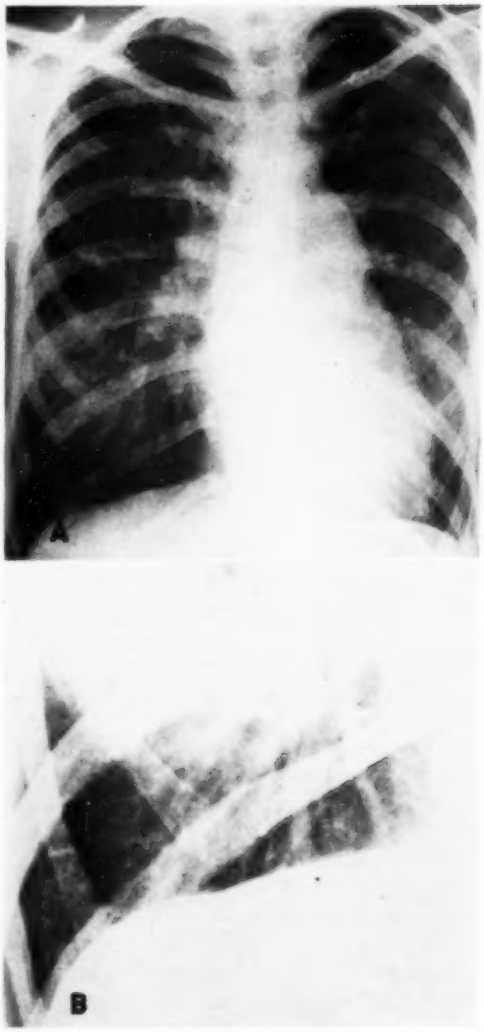

Fig. 1. A. Roentgenogram of the chest of a nineteen-year-old female with ventricular septal defect and minimal pulmonary hypertension (systolic pulmonary artery pressure 40 mm. Hg), showing Kerley's lines.
B. Enlarged reproduction of right lower lung field of same patient to show Kerley's lines near costophrenic angle.

Cyanosis was encountered in only one-third of the patients with pulmonary hypertension and was not related to the severity of the latter. In most patients the cyanosis was minimal; it was usually associated with exertion.

Polycythemia occurred in one-third of the patients. Most of those who were cyanotic were polycythemic as well. The

D.O. 15 VSD 130 0 + + + + + + + + + 0

* ASD. Atrial septal defect. VSD. Ventricular septal defect. PDA. Patent ductus arteriosus.

Fig. 2. A. Roentgenogram of the chest of a thirty-four-year-old male with ventricular septal defect and pulmonary hypertension (systolic pulmonary artery pressure 101 mm. Hg), showing marked disparity between the proximal and peripheral pulmonary artery size.

B. Roentgenogram of the chest of a seven-year-old male with atrial septal defect without pulmonary hypertension, showing prominent hilar and peripheral vessels without disparity in size.

TABLE II: INCIDENCE OF POSITIVE SIGNS IN 51 CASES OF CONGENITAL HEART DISEASE WITH AND WITHOUT PULMONARY HYPERTENSION

	Pulmonary Hypertension (No. of cases)	Normal Pulmonary Pressure (No. of cases)
Cyanosis	12(33%)	0
Polycythemia	12(33%)	0
Cardiac enlargement	30(83%)	12(80%)
Right ventricular enlargement	30(83%)	11(73%)
Pulmonary artery enlargement	33(92%)	13(87%)
Perihilar vessel enlargement	35(97%)	14(93%)
Relative narrowing of peripheral pulmonary arteries	23(64%)	0
Tortuosity of peripheral pulmonary arteries	9(25%)	0
Kerley's lines	5(14%)	2(13%)

incidence of polycythemia, like that of cyanosis, was unrelated to the degree of pulmonary hypertension.

Cardiac enlargement was present in 83 per cent of the cases of pulmonary hypertension. This finding is not specific, an almost identical incidence being found in the patients with normal pulmonary artery pressures. No correlation was discovered between the degree of cardiac enlargement and the magnitude of pulmonary hypertension. Whitaker and Lodge (1), in their study of mitral valvular disease, report a somewhat similar observation, though they state that a heart of normal size suggests that pulmonary hypertension is of no more than mild degree. This is not borne out by the present study, since 3 of the patients had systolic pulmonary artery pressures over 100 mm. Hg without any roentgen evidence of overall cardiac enlargement.

Right ventricular enlargement was noted, roentgenographically, in 83 per cent of the patients with and 73 per cent of those without pulmonary hypertension. No correlation between the degree of right ventricular enlargement and the degree of hypertension was found.

Main pulmonary artery enlargement occurred in 92 per cent of the patients with pulmonary hypertension, but was also found in more than two-thirds of those without hypertension. It was not possible to relate the amount of enlargement of the artery to the degree of pressure elevation.

Perihilar vessels were found to be increased in size in all but one (97 per cent) of

the patients with pulmonary hypertension and in 93 per cent of those without hypertension. No relationship between the size of the perihilar vessels and degree of pulmonary hypertension was observed.

Relative narrowing of the peripheral pulmonary arteries, as compared with the proximal pulmonary arteries, was seen in 64 per cent of the cases of pulmonary hypertension, and in none of the patients without pulmonary hypertension. This finding refers to those arteries which failed to diminish gradually in caliber as they extended peripherally but, instead, manifested an abrupt decrease, usually adjacent to the dilated hilar portion of the artery. Determination of such disparity in size was based solely upon subjective impressions. Actual measurement of the arteries would be desirable, but the difficulty of selecting proper vessels in identical areas of the lungs in each patient rendered such measurement unrewarding.

Fig. 3. Roentgenogram of the chest of a boy of sixteen with ventricular septal defect and pulmonary hypertension (systolic pulmonary artery pressure 95 mm. Hg), showing no evidence of disparity between proximal and peripheral pulmonary artery size.

In Figure 2A is shown the film of a patient with pulmonary hypertension, demonstrating the relative narrowing of the peripheral vessels. Figure 3, which illustrates another case of pulmonary hypertension, is included to emphasize that this sign is not a necessary accompaniment of hypertension.

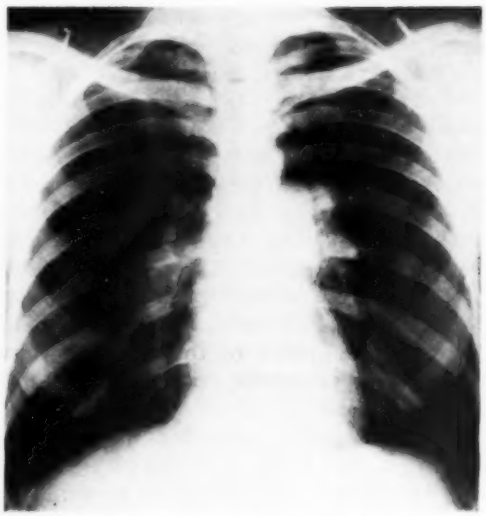

Fig. 4. Roentgenogram of the chest of a forty-year-old woman with atrial septal defect and pulmonary hypertension (systolic pulmonary artery pressure 77 mm. Hg), showing marked relative narrowing of the peripheral arteries with only moderate elevation of pulmonary artery pressure.

No demonstrable relationship between the degree of narrowing of the peripheral vessels and the degree of pulmonary hypertension was observed. Some of the most marked examples of peripheral vessel narrowing were seen in patients with only moderate elevation of pulmonary pressure (Fig. 4).

It should be pointed out that, in the absence of enlargement of the perihilar vessels, it is difficult to evaluate relative narrowing of the peripheral pulmonary arteries.

Davies *et al.* (2) have described *tortuosity of the peripheral pulmonary arteries* as an early sign of pulmonary hypertension in mitral stenosis. We found it difficult to evaluate this feature in the presence of the increased pulmonary vascularity seen in these congenital heart lesions; it could be detected with certainty in only 9 cases

(25 per cent). No correlation between the occurrence of tortuosity and the degree of pulmonary hypertension was noted.

Kerley's lines were present in only 5 cases of pulmonary hypertension due to congenital heart disease. The systolic pulmonary artery pressures in all cases showing Kerley's lines, including those without pulmonary hypertension, ranged from 17 to 102 mm. Hg. Whitaker and Lodge and Carmichael *et al.* have stated that in mitral valvular disease Kerley's lines are an index of the degree of pulmonary hypertension; they found these lines only in cases of moderate or severe hypertension. This does not appear to be the case in congenital heart disease. Kerley's lines were seen to a minimal degree in 2 cases (13 per cent) without pulmonary hypertension. We are not yet certain of the significance of these lines in congenital heart lesions.

Size of the Pulmonary Veins: The roentgen appearance of the pulmonary veins in heart disease has recently been studied at the institution from which this report comes (14), and their enlargement in cases of increased pulmonary blood flow has been described. Though enlargement of the pulmonary veins was noted in 55 per cent of our present series, no relationship was evident between their caliber and the occurrence or degree of pulmonary hypertension, or between their caliber and the size of the peripheral pulmonary arteries.

Age of Patients: It was anticipated that there might be a trend toward higher degrees of pulmonary hypertension with increasing age, but this was not the case. No such correlation was observed.

Type of Congenital Defect: We were unable to find any relationship between the degree of hypertension and the type of congenital defect present. While this series is not large enough to be statistically significant, it is interesting to note that 8 of the 36 patients with pulmonary hypertension had atrial septal defects. This is contrary to the impression commonly held that in patients with atrial septal defects pulmonary hypertension does not often develop.

Hultgren *et al.* (10) reported a series of 8 cases of patent ductus arteriosus with pulmonary hypertension in which all the patients had large right ventricles, large pulmonary arteries, and right ventricular hypertrophy as determined electrocardiographically. Our 5 patients with patent ductus arteriosus showed similar findings and, in addition, there was relative narrowing of the peripheral arteries in all of our cases. Right ventricular enlargement and disparity between the size of the central and peripheral pulmonary arteries are apparently good indicators of pulmonary hypertension in patients with patent ductus arteriosus.

Correlation of Roentgen Signs with Calculated Pulmonary Blood Flow: The absence of demonstrable correlation between the degree of pulmonary hypertension and the roentgen signs of cardiac enlargement, right ventricular enlargement, prominence of the main pulmonary artery, increased size of the perihilar vessels, and size of pulmonary veins led to an attempt at evaluation of a possible relationship between the magnitude of these roentgen signs and calculated pulmonary blood flow. The incidence of cyanosis, polycythemia, vessel disparity, and the presence of Kerley's lines was also considered in this evaluation. Pulmonary blood flow was calculated on the basis of arteriovenous oxygen differences in the pulmonary and systemic circulations and was expressed as a ratio of pulmonary to systemic flow.

Cyanosis was observed clinically in 4 of the 6 patients with pulmonary blood flow indicating a right-to-left shunt; all of the 6 were polycythemic.

None of the roentgen signs consistently correlated in magnitude with pulmonary blood flow. Increasing pulmonary blood flow, however, was associated with a definite trend toward increase in size of the cardiac silhouette, the right ventricle, and the pulmonary artery, substantiating the work of Healey and his co-workers (15). No consistent relationship could be de-

tected between pulmonary blood flow and the degree of enlargement of the perihilar vessels, the disparity between proximal and peripheral vessel size, and the presence of Kerley's lines.

It is of interest that in none of the cases with right-to-left shunts was enlargement of the pulmonary veins demonstrated, whereas such enlargement was frequently found in the group with left-to-right shunts.

CONCLUSIONS

Of the roentgen criteria described for the detection of pulmonary hypertension in mitral valvular disease, only disparity of proximal and peripheral pulmonary vessel size is useful in congenital heart disease. When present, this finding is sufficiently marked in most cases to be quite striking. Reliance should be placed upon this sign only when it is unequivocal. Cardiac enlargement, right ventricular enlargement, and enlargement of the main pulmonary artery and perihilar vessels may all be found in the presence of left-to-right shunts unassociated with pulmonary hypertension and therefore are not reliable criteria.

No consistent relationship between the presence of Kerley's lines and pulmonary hypertension was found; neither could a consistent relationship between pulmonary vein size and hypertension be determined. The severity of the roentgen signs observed did not correlate with the degree of pulmonary hypertension. Cyanosis and polycythemia were usually concomitant findings and were present in only one-third of the cases with high pulmonary pressures.

SUMMARY

Thirty-six cases of proved pulmonary hypertension associated with interatrial septal defects, interventricular septal defects, or with patent ductus arteriosus were reviewed in an attempt to determine if the criteria established for the roentgen detection of pulmonary hypertension in mitral valvular disease could be applied also in congenital heart disease. The only one of these criteria which proved applicable was disproportionate narrowing of the peripheral pulmonary arteries as compared to the proximal arteries. This sign was present in 64 per cent of the series studied. The other reported signs of right ventricular and pulmonary outflow tract enlargement occur in the presence of left-to-right shunts without pulmonary hypertension and are, therefore, unreliable as indicators of the presence of pulmonary hypertension. The degree of enlargement of the heart, right ventricle, and the pulmonary artery appears to correlate more closely with the magnitude of pulmonary blood flow.

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SUMARIO

Las Manifestaciones Roentgenológicas de la Hipertensión Pulmonar en las Cardiopatías Congénitas

Tratando de determinar si las pautas establecidas para el descubrimiento roentgenológico de la hipertensión pulmonar en las afecciones de la válvula mitral encuentran igual aplicación en las cardiopatías congénitas, repasáronse 36 casos comprobados de hipertensión pulmonar asociada con malformación del tabique interauricular, malformación del tabique interventricular o conducto arterioso permeable. El estrechamiento desproporcionado de las arterias pulmonares periféricas, comparado con el de las arterias proximales, pareció ser la única pauta aceptable, observándose en 64 por ciento de la serie de los AA.

Recálcase que no debe confiarse en este signo más que cuando su presencia es inequívoca. Otros signos descritos, tales como hipertrofia cardíaca, hipertrofia del ventrículo derecho, hipertrofia de la principal arteria pulmonar y de los vasos perihiliares, también aparecen cuando existen desviaciones de derecha-a-izquierda sin asociación con hipertensión pulmonar, y no constituyen por lo tanto pautas fehacientes. No se observó relación constante entre las finas líneas horizontales de la periferia de los pulmones cerca del ángulo costofrénico (líneas de Kerley) y la hipertensión pulmonar; y tampoco pudo descubrirse ninguna relación constante entre el tamaño de la vena pulmonar y la hipertensión. No pudo correlacionarse la gravedad de esos varios signos roentgenológicos con la intensidad de la hipertensión pulmonar.

Segmental Infarction of the Small Bowel[1]

BERNARD S. WOLF M.D., and RICHARD H. MARSHAK, M.D.

IMPAIRMENT OF the blood supply to the intestinal tract produces a variety of pathologic changes which may be reflected in roentgen studies. In general, such circulatory disturbances are secondary to strangulating obstructions, as a volvulus or strangulated hernia, or primary, as a result of occlusion of the veins and arteries of the bowel by thrombi or emboli. In the majority of cases, these conditions constitute a surgical emergency requiring prompt intervention. There is a small group, however, in which short segments of small bowel become only partially devitalized instead of undergoing gangrene of the entire wall and perforation. In such an event, healing may occur and be followed by stenosis. The patient may then present the findings of intestinal obstruction of unknown etiology. Barium studies are usually performed for diagnostic purposes, and differentiation from other, particularly neoplastic, causes of obstruction becomes a problem.

The purpose of this paper is to describe the roentgen findings in a group of cases with small bowel infarction which did not go on to complete recovery, but rather to segmental stenosis and intestinal obstruction. The term "segmental" is used because the area of stenosis is relatively small, measuring 3 to 6 inches in length.

As a prototype of this group, an example of an incarcerated and strangulated hernia will be described. In this instance, a loop of bowel, originally considered viable, was replaced into the abdominal cavity, but segmental stenosis and intestinal obstruction supervened, requiring a laparotomy.

CASE I: A 54-year-old female was seen with a right femoral hernia containing a loop of ileum. At operation, this loop appeared discolored, but, after injection of novocaine into the mesentery and the application of hot pads for about twenty minutes, the color appeared to improve and peristaltic activity was noted. The ileal loop was therefore returned to the abdomen and the wound closed.

Fig. 1. Case I. Reduced strangulated hernia. Segment of ileum, about 6 inches in length, showing tubular stenosis with effacement of the mucosal pattern and conical transition to proximal dilated bowel.

Three weeks after operation, symptoms of intestinal obstruction appeared. Administration of barium by mouth revealed a segment of tubular stenosis in the proximal ileum measuring about 6 inches in length, which appeared to be angulated on itself. The small bowel for a short distance proximal to the narrowing was moderately dilated. The mucosal pattern in the stenotic segment was completely effaced, and there was a fairly abrupt but somewhat conical transition to the normal dilated bowel proximally (Fig. 1). There was no evidence of any overhanging edge or nodular defect within the narrowed segment.

The patient was re-explored, and the narrowed segment of ileum was identified and found to be adherent to the anterior abdominal wall and to the adjacent dilated loops of small bowel, forming a rather acute S-shaped curve. The involved ileum was excised and a side-to-side isoperistaltic enteroenterostomy was performed. Postoperatively, the

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patient made an uneventful recovery. The specimen consisted of a segment of ileum about 12 inches in length. For a distance of about 6 inches in its mid-portion, the bowel wall was fibrotic and its lumen narrowed. The mucosa in this region was atrophic and valvulae were absent.

This type of case, repeatedly described in the literature (1, 4, 7, 9), demonstrates the fact that an infarcted loop of small bowel may not be so completely devitalized as to lead to gangrene and perforation. It has been shown by several observers (5, 10) that the different layers of the bowel wall are not equally sensitive to interference with their blood supply. The mucosa appears to be most dependent on an intact blood supply, since mucosal ulceration occurs first. The muscular fibers are next involved, but the connective-tissue elements, both submucosal and subserosal, may maintain their viability for a considerable period. It is therefore possible to speak of incomplete or partial infarction of a loop of small bowel, in which all of the layers do not undergo complete devitalization. This, of course, is dependent on the maintenance of some circulation, presumably through anastomoses, and also, to a marked degree, on the ability to control infection of the compromised bowel by intestinal organisms. It is well known that the mucosa of the bowel has extensive powers of regeneration provided there is no interference with the blood supply. It has also been demonstrated (8) that revascularization of a partially infarcted loop may occur following the administration of antibiotics. Restitution to a completely normal state will not occur, however, if there have been extensive mucosal destruction and persistent limitation of vascular supply. Instead, inflammatory granulation tissue forms, with subsequent fibrotic changes causing a stricture. As in an ordinary mechanical obstruction, dilatation of the bowel proximal to the stricture occurs, terminating abruptly in a narrowed, firm tubular structure 2 to 5 inches in length and one-half to one-quarter the diameter of the normal bowel. The mesentery of the involved segments is also thickened and fibrotic, with hyperplastic lymph nodes.

The second case is another example of segmental stenosis following partial or incomplete infarction of known etiology. In this instance, the cause was venous occlusion on the basis of thromboangiitis obliterans.

CASE II: A 40-year-old white male entered the hospital with symptoms of intestinal obstruction. A year earlier, the first and second toes of his left foot had been amputated because of gangrene. On admission, the temperature was 101° and the white blood cell count was 14,000, with 78 per cent polymorphonuclears containing toxic granules. The day following admission, the patient had three successive spontaneous bowel movements. The obstruction was relieved, and what appeared to be a cast of small intestine was discovered in the stool. Pathological examination of this material confirmed the fact that it represented necrotic small intestinal wall, 18 cm. in length. Two weeks later, barium was administered through an indwelling Harris tube. A loop of bowel, apparently in the mid-jejunum (Fig. 2A), about 4 inches in length, appeared to be somewhat narrowed and fixed. The mucosal pattern in this area was indistinct. The bowel proximal to the narrowed segment was moderately dilated. A second loop of dilated bowel more distally located, presumably in the proximal ileum, was also observed at this examination. However, no stenotic segment to account for this second area of dilatation was visualized. One week after this examination, another whitish, worm-like structure was passed in the stool, 8 inches in length and $\frac{1}{2}$ inch in width. Pathologic examination again revealed completely necrotic tissue; the shape and microscopic appearance suggested necrotic intestinal mucosa and submucosa without muscularis. Three weeks later, the patient again exhibited symptoms of partial intestinal obstruction, which became complete in several days, requiring exploratory laparotomy.

At operation, a narrowed segment of bowel measuring 4 cm. in length was located and resected. In the same region, there were multiple matted loops of bowel with purulent exudate, presumably the result of a small perforation. Complete exploration of the small bowel was not done because of the presence of infection. Pathological study of the excised segment revealed fibrosis of the bowel wall and of the mesentery.

Symptoms of partial intestinal obstruction continued after operation, and a repeat barium-meal examination revealed an area of marked stenosis, about 2 cm. in length, in the proximal ileum. The transition from dilated bowel to the narrowed segment was abrupt, but cone- or funnel-shaped (Fig. 2B). Re-exploration was performed and a second area of stenosis identified and resected. Patho-

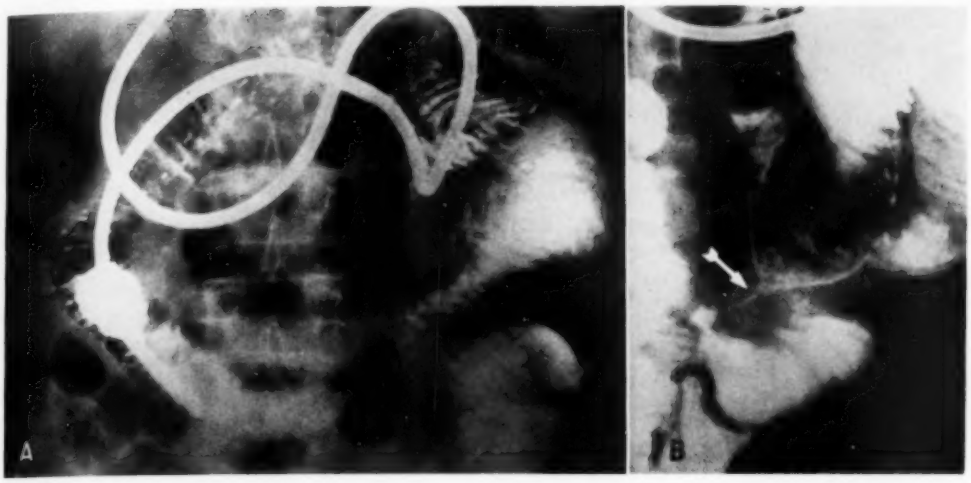

Fig. 2. Case II. Thromboangiitis obliterans. A. Narrowed segment in mid-jejunum with effacement of mucosa. B. Markedly stenotic segment about 2 cm. in length in proximal ileum.

logical examination of the specimen showed it to be ileum with acute and chronic inflammation and mucosal destruction. Of special interest was the discovery of an obliterating endophlebitis of the mesenteric veins. Following the second operation, the patient made a gradual recovery and was discharged.

Except for the recognized inflammatory basis of the venous thrombosis and the multiplicity of the lesions, this case also serves as an example of segmental infarction with roentgen and pathological findings similar to those noted above in strangulated hernia. It is likely that there was actually an extensive phlebitis of the mesenteric veins, despite the fact that only short segments of bowel underwent incomplete infarction and stenosis.

The 2 cases described above are of special importance in the interpretation of the next 2, since we believe that the roentgen and pathological findings are essentially identical. However, in the cases to be recorded an exact etiology could not be proved. They must then be labeled as segmental infarction and stenosis of unknown etiology, though it is assumed that the underlying cause is mesenteric occlusion, either on a thrombotic or embolic basis.

CASE III: A 61-year-old male complained of cramp-like pain in the left upper quadrant for approximately twelve days. The past history was non-contributory. Barium-meal examination revealed considerable irritability and spasm of the distal half of the jejunum (Fig. 3A). In some areas, the folds appeared to be thickened and somewhat distorted and blunted. The individual loops of bowel were separated from one another, as if by thickening of the mesentery, and had an uncoiled appearance. The remainder of the gastrointestinal tract appeared normal. The significance of the changes in the jejunum was not clear.

The patient was observed carefully and several diagnoses were entertained, such as acute pancreatitis, coronary thrombosis, and diverticulitis. A barium-enema examination was negative. Serial electrocardiograms disclosed no abnormality. The diagnosis of acute pancreatitis could not be sustained by laboratory evidence. Over a period of three weeks, the symptoms became clearly those of a partial intestinal obstruction. Barium was again administered by mouth and this time revealed an area of tubular narrowing in the distal jejunum, which was constant. The lumen of the bowel was markedly constricted for a distance of about 4 cm. The mucosal pattern within this segment was effaced and the transition to the dilated proximal bowel was funnel-shaped, symmetrical, and smooth, with no evidence of an overhanging edge (Fig. 3B). An unusual finding was the presence of slight dilatation of the bowel for a short distance distal to the narrowed segment, also showing a funnel-like transition to the area of narrowing.

The nature of this lesion could not be clearly determined from the roentgen examination, but it was considered to be a benign process. At laparotomy, the narrowed segment was found and resected, and a side-to-side anastomosis was performed. The path-

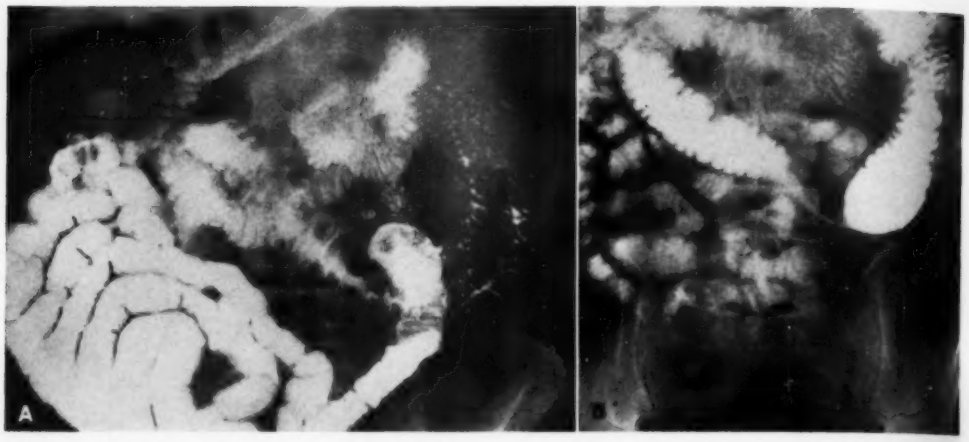

Fig. 3. Case III. Incomplete mesenteric infarction. A. First examination. Spasm of multiple jejunal loops with separation and "uncoiling." B. Seven weeks after first examination. Narrowed segment in distal jejunum with effacement of the mucosa and conical transition to dilated bowel both proximally and distally.

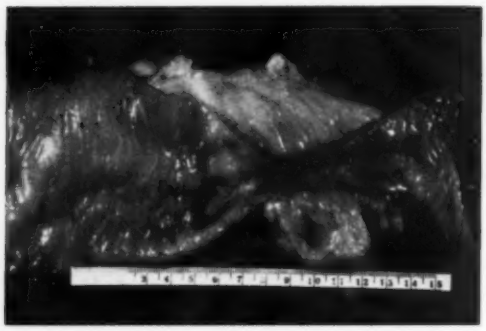

Fig. 4. Case III. Gross specimen of incomplete infarction. Tubular fibrotic segment, 7 cm. long, with conical transition to adjacent bowel.

ological findings (Fig. 4) will be quoted in detail to indicate the similarity to the cases of known etiology described above:

"The specimen (Fig. 4) consists of a 23-cm. segment of resected small bowel showing a fairly sharply defined 7-cm. markedly narrowed segment beginning 4 cm. from one end. At the narrowest portion, the bowel lumen is only 1 cm. in internal circumference. From here, it expands to 3 cm. on one side of the narrowing and 6 cm. on the opposite side. These borders are marked by a red and somewhat hemorrhagic linear zone which separates normal appearing mucosa, which is freely mobile and shows the normal folds, from the granular pinkish-grey and adherent surface of the constricted portion. Some tannish-grey, apparently necrotic material overlies the narrowed portion at its wider end. At the resected margins, the internal circumference of the bowel lumen measures 7 and 9 centimeters. The wall in this widened portion of the bowel shows a thickened muscularis and a freely mobile, normal appearing mucosa, which is perhaps slightly edematous. The mesenteric fat in the region of the narrowing is slightly increased and more lobulated. Many fibrous adhesions, which are hemorrhagic, cover the entire length of the serosal surface of the narrowed segment. The lymph nodes are moderately enlarged, somewhat firm, and on section uniformly tannish-grey. Small mesenteric vessels noted on section of the mesentery do not appear remarkable. *Diagnosis:* Fibrosis of jejunum with chronic nonspecific inflammation and stenosis. Fibrosis should be interpreted as a result of previous necrosis of the wall, probably secondary to a vascular insult."

Of special interest in this case was the first barium-meal examination, when the symptoms were those of an acute abdominal episode rather than intestinal obstruction. In retrospect, it would appear that a fairly extensive mesenteric vascular insufficiency was present at that time which went on to complete recovery except for a short segment of maximal involvement. Partial infarction in this segment then progressed rather rapidly to fibrosis and stenosis.

The assumption that this infarcted segment had previously been associated with more widespread impairment of the blood supply to the small bowel appears to be a better explanation of the appearance of segmental stenosis than the assumption that a small area was infarcted as a result of occlusion of a single small vessel. Ex-

perimentally, occlusion of a single small vessel in the small bowel does not result in permanent damage because of the excellent anastomotic circulation. There is no doubt that the condition of the patient at the time of mesenteric occlusion is of importance in the subsequent development of infarction. In the presence of chronic stasis, shock, or infection, infarction is more likely to occur (6).

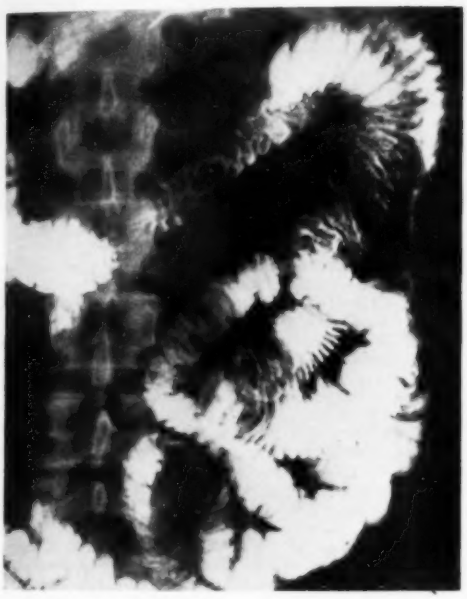

Fig. 5. Case IV. Incomplete mesenteric infarction. Segment of mid-jejunum with tubular stenosis, effacement of mucosal pattern, no evidence of mass.

CASE IV: A 50-year-old man complained of low abdominal pain with distention and vomiting for five weeks. Roentgen examination elsewhere, one week after the onset of his illness, was interpreted as small-bowel obstruction. On admission, there was rather marked tenderness in the left upper quadrant, but the remainder of the examination was essentially negative. The patient gave a history of an episode of coronary thrombosis four years prior to entering the hospital.

Barium administered by mouth demonstrated a normal esophagus, stomach, and duodenum. The jejunum, however, was considerably dilated to its mid-portion. At this site, a segment of narrowing (Fig. 5) about 4 cm. in length was visualized. The mucosal pattern in the narrowed segment was effaced. There was no evidence of an associated mass. The findings were considered similar to those in the previous case, and a tentative diagnosis

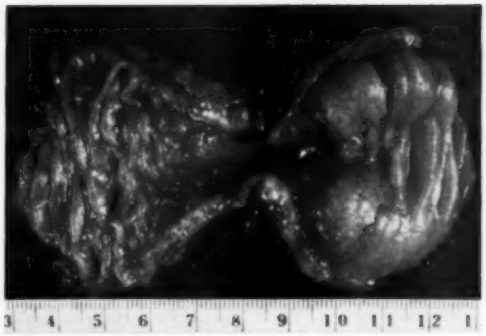

Fig. 6. Case IV. Gross specimen of incomplete infarction. Segment of mid-jejunum with fibrotic tubular stenosis.

of segmental stenosis on the basis of partial infarction was made.

At operation, a stenotic segment measuring about 4 cm. in length and located about 16 inches from the ligament of Treitz was found. Resection and conventional anastomosis were performed. The pathological changes (Fig. 6), both grossly and microscopically, were essentially similar to those in the preceding case.

Comparison of the specimens of the last 2 cases with those of segmental stenosis following strangulated hernia, as seen in the first case and other published cases, revealed an identical appearance.

ROENTGEN FINDINGS

The roentgen findings in segmental infarction or stenosis have been described above in individual cases. They consist of tubular narrowing of a segment no longer than 6 inches and usually no more than 3 inches (Figs. 2B, 3B, 5), with effacement of the mucosal pattern but none of the characteristics of mucosal destruction and no evidence of nodular irregularity of the lumen or overhanging edges. The degree of narrowing is variable, dependent on the progress of the disease. The transition to the dilated bowel proximal to the lesion and to the distal bowel is smooth, concentric, and usually fairly abrupt. These findings may be contrasted with segmental changes in other conditions (Fig. 7). In Case II, described above, in which an original episode of mesenteric occlusion or insufficiency was observed, the findings of spasm, irritability, mucosal and mesenteric

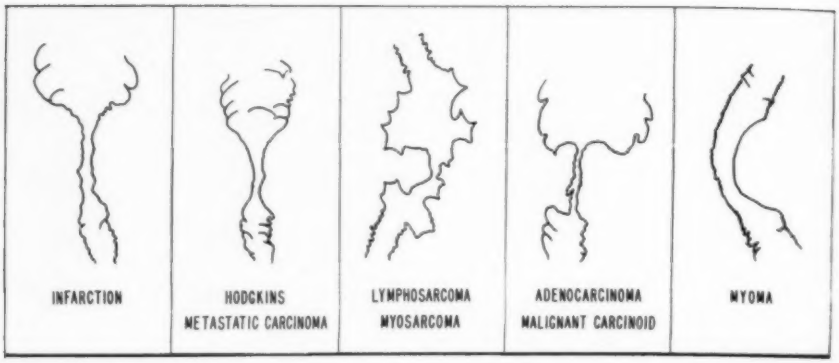

Fig. 7. Varieties of discrete small bowel lesions. Roentgen features of diagnostic value represented in diagrammatic fashion. Characteristic findings in neoplastic cases may not be present.

thickening are similar to those described in the early stages of mesenteric occlusion in experimental animals (2). In contrast to the late stages of mesenteric occlusion with gangrene of the bowel, there was no remarkable stasis, no evidence of dilatation of the bowel wall, and no flabbiness or marked irregularity of the contours of the involved segments. The fact that some dilatation may persist for a short distance distal to the area of infarction after stenosis develops suggests that there may be a continuation of a physiologic disturbance which is more evident in the acute stage.

CONCLUSION

The roentgen findings in 4 cases of segmental stenosis of the small bowel following partial infarction have been described. In 2 cases, the etiologic diagnosis is not certain, but the roentgen and pathological findings were identical to instances of known vascular compromise.

NOTE: The authors extend their appreciation to Dr. Isidore Snapper for Case II and Dr. Harry Yarnis for Case IV.

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SUMARIO

Infarto Segmental del Intestino Delgado

Preséntanse los hallazgos radiológicos en 4 casos de estenosis segmental del intestino delgado consecutiva a infarto parcial. En un caso, el infarto fué consecuencia de una hernia estrangulada y en uno de oclusión venosa incidente a tromboangiítis obliterante. En los otros 2 casos, no pudo hacerse positivamente un diagnóstico etio-

lógico, pero los hallazgos roentgenológicos e histopatológicos eran semejantes a los debidos a trastornos vasculares conocidos.

Los hallazgos radiológicos consisten en estrechamiento tubular de un segmento que no pasa de 15 cm., y por lo general de 7.5 cm., de largo, con desaparición del patrón de la mucosa, pero sin ninguna de las características de destrucción de ésta y sin signos de irregularidad nodular de la luz intestinal o bordes colgantes. La intensidad de la estrechez varía, conforme al avance de la enfermedad. La transición al intestino dilatado proximal a la lesión y a la porción distal del intestino es lisa, concéntrica y casi siempre bastante brusca.

The Hypothyroid Infant and Child

The Role of Roentgen Evaluation in Therapy[1]

LEE B. LUSTED, M.D.,[2] and DONALD E. PICKERING, M.D.[3]

PERIODIC ROENTGENOGRAMS, in conjunction with repeated serum hormonal iodine determinations, represent useful and important guides to clinical evaluation of therapy in the hypothyroid infant or child. This opinion rests largely upon studies, conducted at the University of California Medical Center, on the role of thyroid in growth and development of athyroid infant monkeys (1–8). These investigations revealed that (*a*) doses of sodium *l*-thyroxine sufficient to promote continuing central-nervous-system growth *and* skeletal growth and maturation at normal rates were similar in quantity and (*b*) that these doses were significantly larger than those required merely *to reverse* superficial signs of thyroid privation and bring about a more normal metabolism of skin, liver, muscle, and the cardiovascular system. Wilkins (9) had previously stressed the relationship between mental and skeletal development during therapy of the hypothyroid child.

Hypothyroid infants and children under treatment in the Endocrine and Metabolic Clinic, Department of Pediatrics, University of California, have been followed in recent years with these points in mind. During this period, those patients who were found to have been inadequately treated were placed on a regimen devised to provide hormone in doses which promote normal skeletal development. It is unfortunate that the majority of cases referred to the Clinic were either undiagnosed or, more often, inadequately treated (by the above standards) during the early critical months of central-nervous-system and skeletal growth and development.

A detailed account of 12 representative cases with correlation of data regarding growth, mental development, metabolic responses, hormone doses, and serum hormonal iodine levels during adequate and inadequate therapy with desiccated thyroid and sodium *l*-thyroxine has been published (10). The present communication is based on roentgenographic observations made during that study. Cases have been selected from the related clinical report to permit a more complete presentation of the roentgen features.

METHODS

Routine serial roentgenograms were obtained as follows: (*a*) postero-anterior of both hands; (*b*) anteroposterior of left elbow; (*c*) anteroposterior of left hip; (*d*) anteroposterior of left knee; (*e*) lateral of left ankle. In infants and young children, the examination was repeated at six-month to one-year intervals. Roentgenograms of the hand and wrist have been found to be of greatest value in evaluation of skeletal maturation during therapy.

Interpretation of the films has been based on the maturity indicators of the individual bones of the hand and the epiphyses as demonstrated in detail by Greulich and Pyle (11). The films presented with each case have been selected to demonstrate (*a*) persistence of retardation during inadequate therapy, and (*b*) rapid progression of maturation with adequate therapy.

Histories of 8 cases are presented in abstract form, in conjunction with critical roentgenograms.

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[1] From the Department of Radiology and the Department of Pediatrics, University of California Medical Center, San Francisco, Calif. Presented in part before the Society for Pediatric Research, Quebec, June 1955. Accepted for publication in April 1955. This study received generous support from the Playtex Park Research Institute and the J. Macleod Moore Estate grant to the University of California.

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(A) Chron. age—5 mo. Bone age—0

(B) Chron. age—12 mo. Bone age—3 mo.

(C) Chron. age—27 mo. Bone age—20 mo.

(D) Chron. age—34 mo. Bone age—36 mo.

Case I

R. S., three-year-old male. Cretinism was first diagnosed at five months of age, at which time the bone age was that of a newborn infant (A). The child was taken away from the clinic after one month of therapy with optimal doses of sodium *l*-thyroxine (0.1 mg./day). At the age of twelve months (B), therapy with sodium *l*-thyroxine was reinstituted (0.1–0.15 mg./day) and continued for a period of nearly two years. On this regimen, skeletal maturation progressed to normal (C and D), although mental retardation persists.

(A) Chron. age—16 mo. Bone age—3 mo.

(B) Chron. age—19 mo. Bone age—6 mo.

(C) Chron. age—26 mo. Bone age—15 mo.

(D) Chron. age—36 mo. Bone age—30 mo.

Case II

C. J. Cretinism was not diagnosed in this female infant until the age of sixteen months, at which time bone age was three months (A). In the succeeding two years, the child was treated with sodium *l*-thyroxine (0.1–0.15 mg./day) and, except for persisting mental retardation, her clinical response was gratifying. After three months of therapy, her bone age had advanced to six months (B). Subsequent roentgen studies at twenty-six and thirty-six months revealed continuing satisfactory skeletal maturation, to fifteen and thirty months (C and D, respectively).

(A) Chron. age—2 mo. Bone age—9

(B) Chron. age—14 mo. Bone age—3 mo.

(C) Chron. age—19 mo. Bone age—3 mo.

(D) Chron. age—31 mo. Bone age—15 mo.

Case III

R. M., male cretin, in whom diagnosis was made at the age of two months (A). Inadequate treatment with desiccated thyroid was continued through the age of eighteen months, during which time the clinical response satisfied parents and physician. The child was then referred to the Endocrine and Metabolic Clinic for evaluation, because of persisting severe mental retardation. During his sixteen months of treatment (15 to 30 mg. desiccated thyroid per day) linear growth was apparent, while skeletal development was barely perceptible (B and C). Subsequent therapy with sodium *l*-thyroxine (0.2 to 0.3 mg./day) brought about a rapid clinical response in growth and skeletal development, though mental retardation persisted (D).

(A) Chron. age—22 mo. Bone age—9 mo.

(B) Chron. age—36 mo. Bone age—30 mo.

(C) Chron. age—42 mo. Bone age—42 mo.

Case IV

L. H., female cretin, in whom diagnosis was made at three weeks of age. Inadequate treatment with desiccated thyroid (15 to 30 mg./day) was given until the age of twenty-two months, at which time the bone age was nine months (A). The child subsequently received adequate amounts of desiccated thyroid (120 mg./day) to the age of thirty-six months, with resultant advancement of bone age to thirty months (B). Therapy thereafter consisted of sodium *l*-thyroxine (0.2 mg./day) from the age of thirty-six to forty-two months, with continuing advancement of bone age to forty-two months (C). Mental retardation persisted.

(A) Chron. age—21 mo. Bone age—9 mo.

(B) Chron. age—29 mo. Bone age—25 mo.

(C) Chron. age—47 mo. Bone age—60 mo.

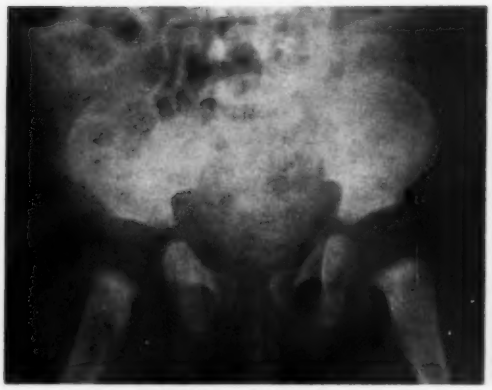
(D) Chron. age—53 mo. Bone age—60 mo.

Case V

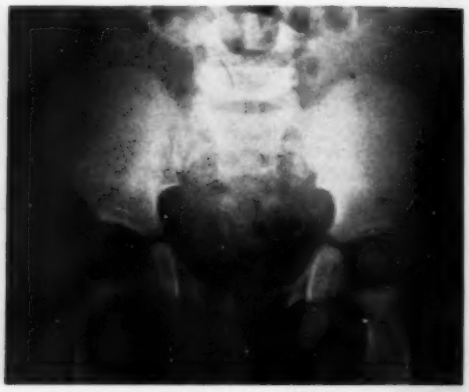
L. B., female child with hypothyroidism developing at approximately six months of age, with diagnosis at twenty-one months, when the bone age was nine months (A). Response to sodium *l*-thyroxine (0.1 to 0.2 mg./day), including mental development, was prompt and continued at a rapid rate. By the age of twenty-nine months, the bone age was twenty-five months (B) and by forty-seven months it was sixty months (C). The accelerated rate of skeletal maturation has diminished with reduced dosage (0.15 mg./day), and during six months of such therapy has advanced only six months (D). The child's intelligence quotient was normal at the time of this report.

(A) Chron. age—8 mo. Bone age—2 mo.

(B) Chron. age—12 mo. Bone age—6 mo.



(C) Chron. age—8 mo.



(D) Chron. age—12 mo.

Case VI

K. O., female cretin in whom diagnosis was made at three months of age. The child was treated inadequately, with desiccated thyroid (15 to 45 mg./day), until the age of eight months, when the bone age was two months (A). Roentgen examination of the pelvis at that time revealed absence of the capital femoral epiphyses (C), normally present by eight months. Subsequent treatment with sodium *l*-thyroxine (0.15 mg./day) for four months resulted in rapid skeletal growth and development. At twelve months the bone age was six months (B) and the capital femoral epiphyses were of normal appearance (D).

DISCUSSION AND SUMMARY

Effects of thyroid privation upon the process of skeletal maturation are illustrated by the accompanying cases. Case II, undiagnosed until the patient reached the age of sixteen months, is an example of extreme delay in skeletal maturation from this cause. At sixteen months, the bone age was three months. Case III demonstrates the significant retardation which can be seen as early as two months. Cases V and VIII show that retardation quantitatively approximates the duration of deficiency in children with acquired hypothyroidism.

The persistence of deficiency in skeletal maturation during periods of inadequate therapy is illustrated by Cases III, IV, VI, and VII. The general clinical response to the inadequate doses given those children had been sufficient to satisfy the parents and supervising physician in each instance and a moderate but significant increase in growth had occurred. It has been the experience of the workers in this laboratory and clinic that smaller amounts of hormone are required for promotion of skeletal growth than for promotion of maturation. Moreover, inadequate or total lack of therapy during earliest childhood, the period when growth potential is at a maximum, is responsible for the

(A) Chron. age—2 1/2 mo. Bone age—0

(B) Chron. age—4 1/2 yr. Bone age—3 yr.

(C) Chron. age—13 yr. Bone age—11 yr.

(D) Chron. age—14 1/2 yr. Bone age—14 yr.

Case VII

J. S., in whom cretinism was diagnosed at two and a half months of age, when the bone age was equivalent to that of a newborn infant (A). Therapy with desiccated thyroid (30–60 mg./day) was instituted and continued until the age of four and a half years, at which time the bone age was three years (B). Thereafter, until the age of thirteen and a half years, the patient received desiccated thyroid in varying doses (90–120 mg./day). Growth, development, and bone age continued to lag (C) until the succeeding year, when bone development advanced more rapidly with optimal sodium *l*-thyroxine therapy (0.2 mg./day) (D). The patient was of dull normal intelligence at the time of the report.

greatest developmental deficiency in the skeleton.

Studies made in other clinics have also indicated that quantities of thyroid required to produce bone maturation exceed those required to produce long-bone growth (12, 13). In addition, it has been observed that the athyroid infant rhesus monkey will show satisfactory reversal of major clinical and biochemical signs of

(A) Chron. age—9 1/2 yr. Bone age—5 1/2 yr. (B) Chron. age—12 1/2 yr. Bone age—12 1/2 yr.

Case VIII

A. P. Following a stormy postoperative course incident to tonsillo-adenoidectomy at the age of four and a half years, this female child became hypothyroid. The condition remained undiagnosed until the age of nine and a half years, at which time the bone age was five and a half years (A). Treatment with sodium *l*-thyroxine (0.2-0.3 mg./day) brought about an excellent clinical response, with rapid resumption of growth and skeletal development. After three years of such therapy the bone age was normal (B). The patient was of normal intelligence.

thyroid deficiency, and limited, though significant, linear growth following administration of about one-half the dose of sodium *l*-thyroxine required to induce normal skeletal maturation (3, 4, 6).

Adequate treatment led to prompt acceleration of skeletal maturation in all of the hypothyroid patients. In Case V, doses exceeding those required for normal growth and maturation of the skeleton were continued for a period of two years (from twenty-one months of age through forty-six months). During that time, the patient's bone age advanced from nine months to sixty months. This effect was easily controlled by a moderate reduction of dosage. Similar examples of excessive maturation in response to large amounts of hormone, either given orally or emanating from idiopathic thyrotoxicosis, have been reported (14, 15).

It is the experience of workers in both this and other clinics that epiphyseal dysgenesis is a skeletal feature of hypothyroid or inadequately treated athyroid patients. One patient in our series (Case VII), after prolonged inadequate therapy (to the age of thirteen years and a half), exhibited pronounced dysgenesis, which was subsequently ameliorated during one year of optimal therapy. Equally significant was Case VI, in which ossification of the capital femoral epiphyses had not occurred at the age of eight months, but

proceeded normally during a four-month period of adequate therapy.

In summary, thyroid privation or inadequate therapy in the congenitally athyroid infant or child during the early, critical months of life is associated with mental retardation and delayed skeletal maturation. Subsequent institution of adequate therapy can satisfactorily reverse related skeletal stigmata, though mental retardation persists. Administration of either desiccated thyroid or sodium *l*-thyroxine, begun at an early age and continued in quantities sufficient to promote immediate and continuing skeletal maturation to normal levels, might better supply the otherwise inadequately treated developing central nervous system.

CONCLUSIONS

1. Roentgenographic features of 8 hypothyroid infants and children observed over long periods of inadequate and adequate therapy are presented. It is suggested that serial roentgenograms of the hands and wrists are a valuable guide to therapy in the hypothyroid infant or child.

2. Increased hormone dosage is indicated when serial roentgenograms of the hand and wrist reveal persisting skeletal retardation.

3. Doses of hormone which are sufficient to reverse many clinical and metabolic signs of thyroid deficiency are often inadequate to promote normal skeletal maturation.

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SUMARIO

El Lactante y el Niño Hipotiroideos: El Papel de la Justipreciación Roentgenológica en la Terapéutica

Las radiografías de 8 lactantes y niños hipotiroideos, demuestran: (*a*) la persistencia del retardo esquelético durante una terapéutica inadecuada y (*b*) el rápido adelanto de la madurez con un tratamiento adecuado. Las radiografías seriadas de las

manos y las muñecas se consideran como guía valioso del tratamiento, hallándose indicada una dosis mayor de hormona cuando las radiografías revelan persistente retardo esquelético. Sin embargo, dosis de hormona que bastan para virar muchos signos elínicos y metabólicos de deficiencia tiroidea resultan a menudo inadecuadas para fomentar la madurez normal del esqueleto.

En el niño congénitamente atiroideo, la falta de terapéutica o una terapéutica inadecuada durante los primeros meses críticos de la vida se asocian con retardo intelectual y demora de la madurez esquelética. La subsiguiente iniciación del tratamiento adecuado puede invertir los estigmas esqueléticos, aunque persista el retardo intelectual. La administración de tiroides desecado o de *l*-tiroxina sódica, comenzada a una edad temprana y continuada en cantidades suficientes para la inmediata y continua aceleración de la madurez del esqueleto a cifras normales puede afectar favorablemente el sistema nervioso central en vías de desarrollo.

Dermoid Cysts of the Ovary: Roentgen Features[1]

JOSEPH V. CUSMANO, M.D.

THE RADIOGRAPHIC appearance of ovarian dermoid cysts is generally familiar. In the most typical cases, the distinctive finding is a cluster of several calcific tooth-like structures. Recent experience with some atypical cases prompted the author to undertake a study of the material at the Lying-In and New York Hospitals. The findings of this investigation are presented.

PATHOLOGY

Knowledge of the structure of dermoid cysts is an important prerequisite to the understanding of their radiographic appearance. The tumors are cystic, sometimes loculated, and vary from a few millimeters in diameter to the size of a melon. They are distinguishable from teratomas by their cystic nature, but the distinction cannot always be made on a histologic basis alone.

The cyst wall is usually 1 to 3 mm. in thickness. The contents consist of a thick, greasy, lardaceous material, formed by the sebaceous glands of the cyst. In rare instances, when sebaceous glands are absent—the so-called "asebaceous dermoid cyst"—a thin, serous fluid is present. Hairs and rudimentary teeth may sometimes be observed lying free within the cyst. More often, these structures arise from and are embedded in the cyst wall, frequently concentrated about a raised, nipple-like protuberance, the mammilla or dermal plug. The teeth are usually of the incisor or molar variety and may sometimes be contained in a rudimentary fragment of maxillary bone. In addition to these ectodermal structures, such mesodermal elements as cartilage and bone may occur as plaques in the cyst wall.

Microscopically, most of the sebaceous and sudiferous glands and hair follicles appear in the region of the mammilla, while the remainder of the cyst wall is composed of fibrous tissue lined by squamous epithelium.

PHYSICAL CONSIDERATIONS

In the energy range of diagnostic roentgenography, the differences in atomic number of air, water, and fat result in varying degrees of x-ray absorption by those elements. Thus, the soft tissues (muscles and organs), which have an average atomic number of water, cast a grayish-white shadow on the roentgenogram. Calcific structures, with a higher average atomic number and thus greater x-ray absorption, cast a dense white shadow and are termed "radiopaque." Air, having a low atomic number, absorbs the least amount of radiation and therefore appears black; it is "radiolucent." Fat is of lower average atomic number than bone or soft tissue, approaching air in this respect. It therefore appears radiolucent on the roentgenogram. In view of the fatty contents of dermoid cysts, this physical characteristic of fat bears an important relationship to their radiographic demonstration.

AUTHOR'S MATERIAL

During the period 1947 to 1953, 153 operations for ovarian dermoid cyst were done at the Lying-In Hospital (New York) and 28 at the New York Hospital. Roentgenograms were available for study in 35 cases and form the basis of this presentation.

The cyst was evident roentgenographically in all but 5 patients. Three of these were pregnant, at term, and the overlying fetal and uterine shadows probably obscured the lesion. In the other 2, obvious calcific elements were absent.

[1] From the Departments of Radiology and Obstetrics and Gynecology, Lying-In Hospital, New York Hospital-Cornell Medical Center. Accepted for publication in April 1955.

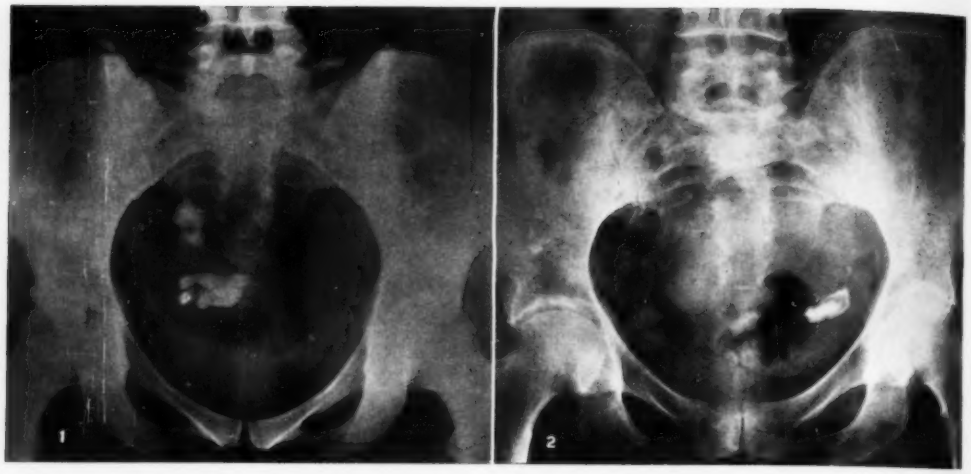

Fig. 1. Large lucent cyst with typical tooth clusters. Note the rudimentary fragments of maxilla in which the teeth are embedded.

Fig. 2. Cyst of water density. The cyst wall is easily seen in several places. This could not occur unless the contents were radiolucent.

Fig. 3. Large lucent cyst with unusual tooth formation. A somewhat banded or mottled appearance is demonstrated but is felt to be due to fecal material and fascial planes. The right lower quadrant density is the result of barium in the colon.

Fig. 4. Bizarre distribution of calcium in a dermoid cyst. No definite lucent areas are evident, and the entire outline of the mass is not well shown. Pathological examination revealed a lobulated tumor, half of which consisted of a typical dermoid cyst. The remaining half was a pseudomucinous cyst.

In addition, poor technic and overlying gas and fecal matter were believed responsible for non-visualization.

In this series some cases were discovered during the course of examination of other organ systems. In view of the high percentage of demonstrated lesions, the value of more widespread use of routine abdominal roentgenograms as a diagnostic tool is obvious.

RADIOGRAPHIC FINDINGS

Lesions with Calcific Densities: Calcific elements were identified in 17 cases. In most instances these were tooth-like structures (Figs. 1–3). In several patients, the calcific material occurred in the form of single or multiple structureless masses, bearing only a faint resemblance to teeth (Figs. 4 and 5). In 1 case, thin calcific plaques outlined the entire cyst wall.

Lesions Without Calcific Elements: In a surprisingly high percentage of cases—41 per cent—no calcific elements were observed. It is in this group that the oily, sebaceous content of the cyst assumes importance. In many of the patients, the only finding was a rounded area of radiolucency, limited by a well defined wall 1 to 3 mm. in thickness. The lucent zone is clear and uninterrupted. The banded or mottled appearance which has been previously described (2) was not seen in this group. Any suggestion of such a change was felt to be due either to superimposed fecal material or to the fascial planes of the gluteal muscles. An apparent water-tissue density displayed by some of the larger cysts is attributed to the view of the normal soft-tissue structures through the translucent "window" of the cyst. Visualization of the cyst wall, however, provides more obvious evidence of the radiolucent content (Fig. 6).

Radiolucency was, of course, a feature of many of the lesions in which calcific elements were observed as well (Figs.

Fig. 5. Enlarged view of cyst on right, in patient with bilateral dermoid cysts. These were associated with an enlarged sarcomatous uterus, with upward displacement of the cyst on the right. Numerous flakes of calcium are well shown here, with little resemblance to teeth.

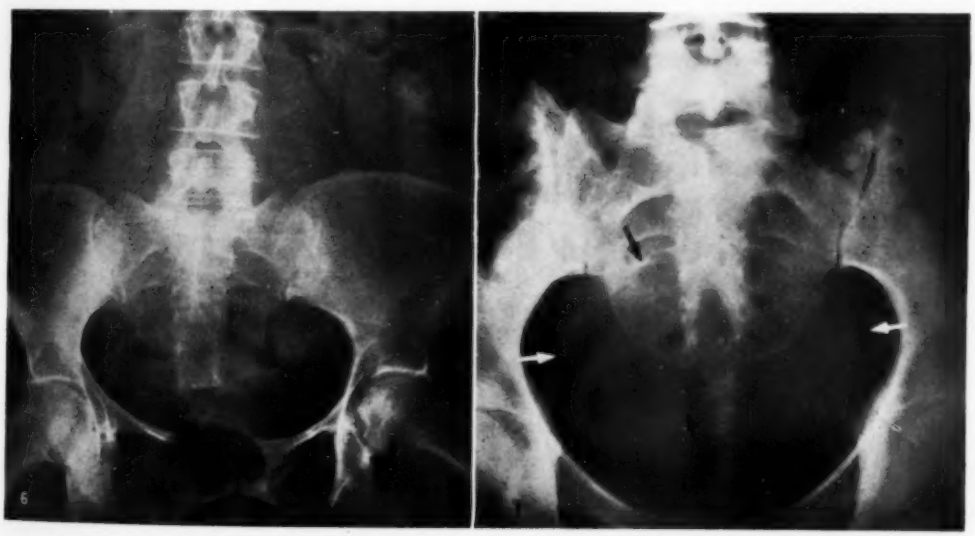

Fig. 6. The largest tumor in the present series. An apparent soft-tissue density is seen; good definition of the psoas shadows and other soft-tissue structures, visible through the translucent "window" of the cyst. The inferior portion of the cyst wall is clearly demonstrated.

Fig. 7. Excellent example of coexistent ovarian cysts. The larger lesion, of soft-tissue density, was found to be a serous cyst (white arrows). Within this area is a rounded, lucent zone representing the dermoid (black arrows).

1, 3, 5). This was, in fact, the most common finding, occurring in a total of 25 instances. Its recognition is important for several reasons. First, it will confirm the diagnosis when suspicion is raised by the presence of calcified, tooth-like structures. Second, it will provide the correct differential diagnosis when associated with less typical calcific densities. Finally, it may represent the only radiographic finding.

Of the remaining cases, 2 are worthy of special mention. The association of serous and pseudomucinous ovarian cysts, Brenner tumors, and fibromas with dermoid cysts is well known (1). The radiographic appearance of these co-existent cysts was particularly well demonstrated in 1 case (Fig. 7), in which such a lesion proved to be a serous cyst. In the other case, although the soft-tissue mass is not well defined on the roentgenogram, a pseudomucinous cyst was discovered as the solid half of a single ovarian mass (Fig. 4). The demonstration, therefore, of a pelvic soft-tissue mass, associated with an area of radiolucency or containing tooth-like structures, should suggest the diagnosis of mixed or multiple ovarian cysts.

DISCUSSION

The most consistent radiographic finding in the group of dermoid cysts reported here was the radiolucent area which appears as a result of the lardaceous contents of the cysts. When unassociated with calcific structures, this feature is not easily recognized. A segment of air-containing bowel, which has similar physical characteristics, can be readily confused with a completely radiolucent cyst. The absence of change in position and contour of the cysts in serial examination, however, serves to differentiate them from bowel.

SUMMARY

1. The radiographic findings in 35 surgically proved ovarian dermoid cysts have been presented.

2. Visualization of the lesion was possible in all but 5 cases.

3. A surprisingly large number of cysts did not contain tooth-like structures or other calcific elements, but appeared as radiolucent areas only.

4. The radiolucent nature of the fatty cyst contents was the most constant radiographic finding.

ACKNOWLEDGMENT: I would like to thank Dr. R. Gordon Douglas, Professor of Obstetrics and Gynecology, Cornell Medical College, and Chief of Obstetrics and Gynecology, Lying-In Hospital, who made available the bulk of the case material in this study.

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SUMARIO

Quistes Dermoideos del Ovario: Características Roentgenológicas

Preséntanse los hallazgos radiográficos en 35 casos de quistes dermoideos del ovario, comprobados quirúrgicamente. En todos, menos 5, fué posible visualizar la lesión. En 41 por ciento, no se observaron tejidos dentados u otros elementos calcificantes. En muchos de estos últimos casos, la radiolucencia producida por el contenido grasoso de los quistes, era el único hallazgo roentgenológico. En el grupo en conjunto, esta zona radioluciente fué la característica más constante.

Varicella Pneumonitis[1]

Z. F. ENDRESS, M.D., and F. R. SCHNELL, M.D.

THE OCCURRENCE of widespread pulmonary infiltration involving all five lobes, without cavitation or calcification, suggests a number of possibilities to the radiologist. It is unlikely, however, that many would consider chickenpox. A case of extensive pneumonitis due to the varicella virus was seen recently and was thought worthy of publication after a search of the radiological literature revealed only two abstracts on the subject and no original papers or illustrations.

Although chickenpox is regarded as the mildest of the various exanthematous diseases of childhood, it can produce serious illness and even death. The incidence of complications at the present time is not known, but before the days of sulfa and antibiotics was reported to be 5 per cent (1). Most of the complications listed were infectious in nature (otitis media, impetigo, septicemia, etc.) and would very likely be prevented today by prophylactic antibiotic therapy. Of Bullowa and Wishik's series of 2,534 cases of chickenpox (1), 21 were complicated by pneumonia, but there is no way of knowing how many of these were due to secondary invaders and how many to the varicella virus. Of the 8 fatal cases, all were shown microscopically to be due to secondary invaders, with no characteristic evidence of a virus pneumonia.

In addition to this large series, 18 cases of varicella pneumonia have been reported (2–17) in the last fifteen years, 1940–55 (a period in which no case of pneumonia from secondary invaders should have occurred). Seven of these had a fatal outcome (3, 4, 5, 9, 11, 15 16), with multiple organ system involvement present in each. The gastrointestinal tract, spleen, liver, kidneys, pancreas, and brain showed invasion by the virus in various combinations. Of these fatal cases, 1 occurred in a premature infant infected by transplacental transmission of the virus (11), 1 in a newborn baby infected during delivery (9), and 1 in a child of eight who also had rheumatic heart disease (15). The other patients were adults between thirty-two and seventy-one years of age (3, 4, 5, 16). Autopsy findings (3, 5, 8, 9, 11, 16) were quite similar from case to case and tissue to tissue: disseminated areas of necrosis in epithelial tissues, with predominantly mononuclear cell infiltration and intranuclear inclusion bodies in the epithelial cells. Grossly, the lungs showed patchy bronchopneumonia with the areas of consolidation tending to confluence but without suppuration.

Of the patients who recovered, all were seriously ill. One of these (12) had severe laryngospasm, probably as a result of involvement of the larynx by "pock" lesions; 5 had hemoptysis, and 1 a hemorrhagic rash, these signs being more common in the fatal group.

Several unusual complications were seen in this collected series. In a case described by Grayson and Bradley (6) there was roentgen evidence of pericarditis with effusion, as well as nephritis; Wesselhoeft and Pearson (17) reported orchitis followed by testicular atrophy; encephalitis was seen by Waring, Neuberger, and Geever (16).

Chest roentgenograms are reproduced in 12 of the case reports but in only 2 (16, 17) was there a follow-up to complete clearing. The findings at the height of the illness were quite similar, varying in degree only. All five lobes were involved, with patchy areas of bronchopneumonia tending to coalesce in the more severe cases but favoring no particular portion of the lung fields. Early regression was rapid, paralleling the course of the skin lesions. Slow but steady improvement followed, and a normal condition was reached by six months in the 2 cases

[1] Accepted for publication in September 1955.

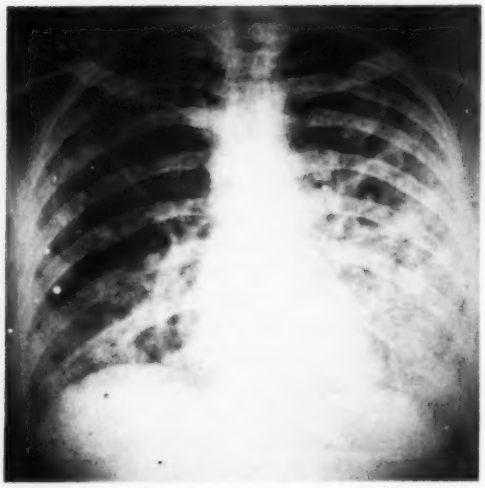


Fig. 1. Roentgenogram of Jan. 12, showing changes involving all five lobes.

followed for that length of time. As in many other pulmonary inflammations, the patients were clinically well long before the roentgen changes disappeared.

Various agents were credited with aiding in recovery (sulfanilamide, sulfathiazole, antistreptococcus serum, and Aureomycin), but in most cases the drug in question was the wonder drug of the moment at which the article was written. Since no sulfa or antibiotic has been found to affect the course of uncomplicated varicella, it is unreasonable to attribute clearing of the pneumonia to anything but the natural course of the disease.

CASE REPORT

Mrs. D. S., aged 32, was admitted to the U. S. Army Hospital, Fort Sill, Okla., Jan. 10, 1954, with the diagnosis of chickenpox, contracted from her daughter. The onset of illness, four days before admission, was marked by back pain, generalized aching, malaise, fever, weakness, and a spreading papulovesicular rash. Coincident with the rash the patient experienced a mild sore throat, a hacking, non-productive cough, and slight dysuria. On the fourth day of illness the rash became partly pustular and densely disseminated, and constitutional symptoms were more severe.

On admission the temperature was 102.4°, pulse 90, respirations 18. The skin showed typical chickenpox lesions, which were most dense on the face, abdomen, chest, and back; none were hemorrhagic. The physical examination was otherwise essentially negative, as were the hemogram and the urinalysis.

Administration of procaine penicillin was begun on the day of admission to prevent secondary bacterial infection of the extensive skin lesions. During the second and third hospital days, new lesions appeared on the skin and oropharynx, accompanied by increasing soreness of the throat and hacking cough, only partially controlled by medication.

By the fourth day, the cough became almost constant; it remained non-productive and was associated with increasing exhaustion, restlessness, and dyspnea, but no cyanosis. Multiple coarse and fine wheezes and rhonchi developed throughout the entire chest, together with fine crepitant râles and frank signs of consolidation at the left base. A chest film taken on Jan. 12 (Fig. 1) showed extensive inflammatory changes in all five lobes. The patient was placed in an oxygen tent and prophylactic antibiotics were increased to 600,000 units of penicillin and 0.5 gm. of streptomycin twice daily.

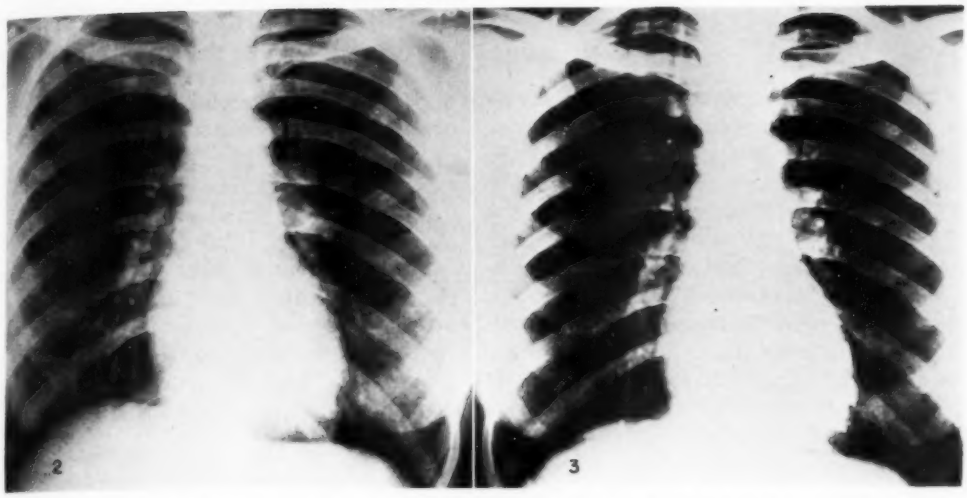
A low-grade fever, never exceeding 102.8°, was present during the first four hospital days, with no elevation above 100° recorded from the fifth day on. By the fifth day not only was the patient afebrile, but pulmonary symptoms had become stabilized and no new skin lesions were seen. During the next two days there were marked lessening of respiratory symptoms, general constitutional improvement, regression of the skin lesions, and resolution of all physical signs of pulmonary consolidation. On the eighth day a second chest film showed marked clearing of the consolidation.

Gradual improvement followed (Figs. 2 and 3) and the patient was discharged from the hospital on the fourteenth day, with all medication stopped. An occasional hacking cough persisted for three months.

COMMENT

In this case of varicella pneumonitis the onset of pulmonary involvement, the parallelism with the skin changes, the normal white blood count, and lack of definite response to antibiotics were quite in keeping with other recorded cases.

The paucity of such case reports in the literature is probably due to the contagiousness of the disease. In the first place, it is so contagious that most adults (in whom it seems more likely to be a severe illness) are immune. Secondly, a patient with chickenpox is usually kept in isolation unless respiratory symptoms become quite severe. It is probable that many cases of lesser pulmonary involvement present few or no symptoms and are never diagnosed.



Figs. 2 and 3. Follow-up films, Feb. 8 and May 7, respectively, showing clearing of the lung fields.

SUMMARY

Pneumonitis caused by the varicella virus is a rare but serious complication of chickenpox (37 per cent mortality in cases reported since 1942). Roentgenographically, it produces a widely disseminated nodular infiltration involving all five lobes, with onset early in the second week of the illness. The lung infiltrates vary a little in size and shape; they are produced by confluence of numerous small areas of consolidation surrounding small foci of necrosis caused by the virus. Initial clearing is rapid and partial; subsequent regression is slow, a period of months elapsing before a normal appearance is finally reached. Clinically, severe dyspnea, cyanosis, and hemoptysis are commonly associated with the condition. Nephritis, encephalitis, hepatitis, pericarditis, orchitis, and laryngitis may accompany the pneumonia.

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SUMARIO

Neumonitis Varicelatosa

La neumonitis provocada por el virus de la varicela es una complicación rara, pero grave, de las viruelas locas (mortalidad de 37 por ciento en los casos comunicados desde 1942). Radiográficamente, produce una infiltración nodular ampliamente diseminada, que afecta los cinco lóbulos pulmonares, con su iniciación en los comienzos de la segunda semana de la enfermedad. Los infiltrados discrepan algo en tamaño y forma, produciéndolos la confluencia de numerosas zonas pequeñas de hepatización que circundan pequeños focos de esfacelo ocasionados por el virus. El despejo inicial es rápido y parcial; la regresión subsiguientes es lenta, transcurriendo un período de meses antes de alcanzarse por fin un aspecto normal. Clínicamente, se asocian comúnmente con la dolencia disnea, cianosis y hemoptisis en forma grave. La neumonía puede acompañarse de nefritis, encefalitis, hepatitis, pericarditis, orquitis y laringitis. Descríbese un caso observado en una mujer de treinta y dos años de edad.

Chickenpox Pneumonia

A Case Report[1]

NATHAN KRISS, M.D.

ALTHOUGH VARICELLA is a common disease of childhood, chickenpox pneumonia is apparently rare. The incidence of varicella virus pneumonia is given as 1 to 8 per 1,000 cases of chickenpox (1, 4). It is generally agreed that adults, although approximately ten times less susceptible to varicella than children (5), are much more prone to the development of a complicating specific virus pneumonia.

Roentgenologically, this condition presents a diffuse miliary pattern. Although non-specific, the picture is sufficiently characteristic to be distinguished from that of secondary bacterial (lobar or bronchopneumonic) consolidations, which also occur as a complication of chickenpox.

Since treatment and prognosis may be influenced by the ability to differentiate between these two conditions, and because it is extremely difficult to identify inclusion bodies in sputum, familiarity with this radiological entity may prove helpful. Claudy (2) reported a case in which both the miliary lesions of chickenpox and a secondary consolidating bronchopneumonic process were recognized on the roentgenogram and verified at autopsy.

CASE REPORT

A 25-year-old colored female was admitted with an extensive vesicular eruption, which had begun four days previously. Dyspnea and cough had appeared two days prior to admission and the sputum became blood-tinged. The patient grew progressively more dyspneic, cyanotic, and prostrated. Shallow, post-vesicular ulceration was observed on the posterior wall of the pharynx. The temperature was 101°, pulse 120, respirations 60/min., blood pressure 120/80, white blood count 11,700. Cold agglutinin tests, blood cultures, and serology were negative.

The patient remained in an oxygen tent in critical condition for four days, improved gradually during the following eight days, and was discharged on the twelfth day, with some cough and extreme fatigue.

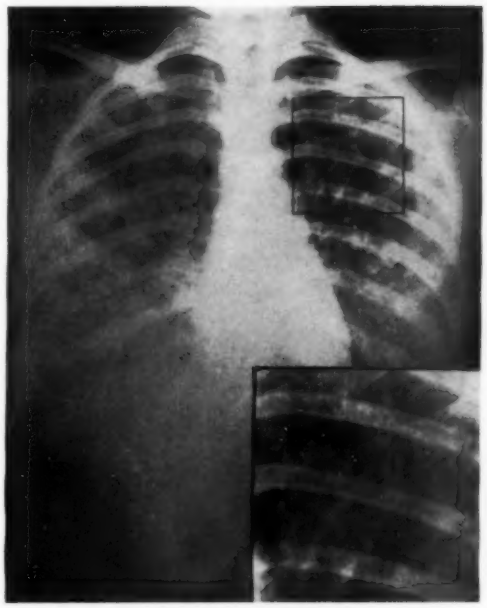

Fig. 1. First film, taken on admission (March 22, 1954) four days after vesicular eruption, showing diffuse miliary pattern with stippling.

Roentgenograms of the chest on admission showed a diffuse miliary pattern with ill-defined densities, a tendency to conglomeration in the mid and lower zones, and a more nodular character in the upper portions. Superimposed on these, and evident also in the clear portions, were discrete, stippled, punctate shadows resembling alveolar-lobular residual Lipiodol fillings following bronchography. A slight prominence of the pulmonary cone was observed (Fig. 1).

Three days later the densities appeared to be less conglomerate, and the peripheral portions of the lungs seemed clearer. In this second study, the stippling was rather more prominent than in the first, probably because the absorption of the perifocal edema afforded a better contrast for these minute lesions. Six days later, beading and coarse reticulation were the outstanding features.

The subsequent regression was slow. Roentgenograms taken after two weeks showed more discrete, dense, uniform miliary lesions with reticulation.

[1] From the Department of Roentgenology of the University Hospital of Virginia, Charlottesville, Va. Accepted for publication in April 1955.

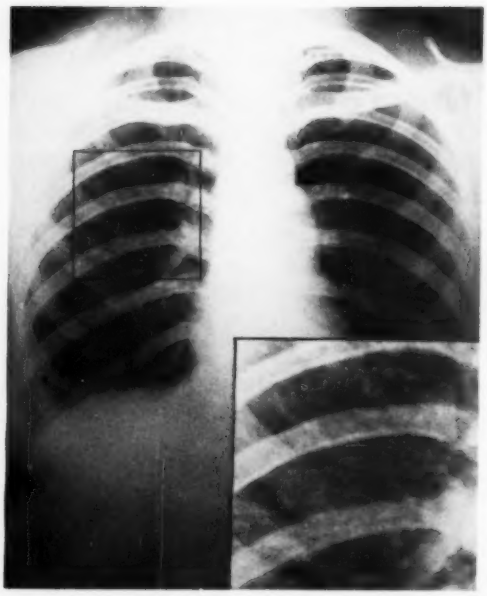

Fig. 2. Fourth film (April 30, 1954), showing marked regression of the miliary nodules. The reticular pattern is more prominent.

Almost six weeks after admission, the nodules were still numerous and the reticular pattern was more prominent (Fig. 2).

On the last x-ray examination of the chest, nine weeks following admission, the nodular densities had disappeared. Minimal reticulation probably was the end-result of the pulmonary process (Fig. 3).

The slow regression of the pulmonary changes of chickenpox pneumonia, over a period of two and one-half months, suggests classification of the condition as a subacute miliary process (4). The miliary appearance of the lesions was complicated, in the case reported, by the initial edema, stippling, and heavy markings. These nodules have never achieved the clear-cut, discrete, independent features of a miliary tuberculosis, even after the obscuring factors of edema and stippling have regressed or disappeared. The anatomical substrate of stippling is possibly an initial exudate in some of the alveoli. It is capable of condensation by the inspired air and of formation of a localized eosinophilic membrane. These changes are common in but not limited to viral pneumonias (6). Beading (nodularities in a mesh pattern) was the main feature of the chest radiographs during the period of one-and-a-half to six weeks following admission; after nine weeks, there remained a fine mesh of interstitial thickening as a visible residuum.

The radiological improvement lags behind the clinical recovery, which generally takes place in one to two weeks. The kind

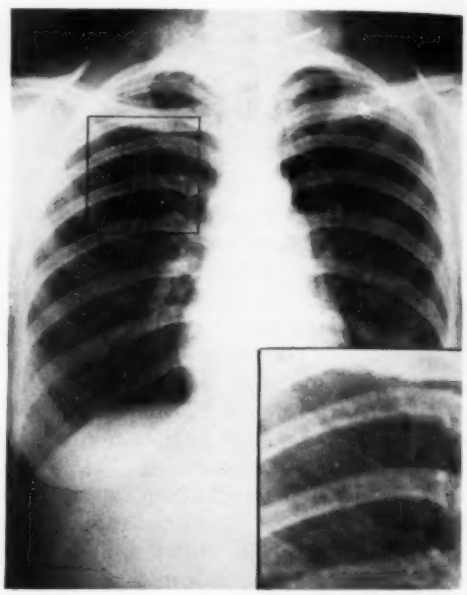

Fig. 3. Fifth film (May 28, 1954), demonstrating disappearance of the nodular densities with minimal reticulation, probably the end-result of the pulmonary process.

of drugs used (sulfa, penicillin, streptomycin, Aureomycin and, in our case, Achromycin) did not seem to affect the rate of regression of the roentgenologic changes, although the clinical course was benefited.

Chickenpox pneumonia is a serious, prostrating illness. It follows the vesicular eruption by not more than five days, most frequently two to three days, and always appears before the vesicles have changed into crusts. Among the eighty conditions said to produce diffuse miliary lesions in roentgenograms (3, 4), chickenpox pneumonia occupies a characteristic place.

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SUMARIO

Neumonía Varicelatosa. Presentación de un Caso

Se describe aquí el aspecto radiológico de la neumonía varicelatosa y se presenta una historia clínica. La dolencia aparece en la radiografía en un patrón granúlico difuso. En el caso actual, las nudosidades (en un patrón de malla) constituyeron la característica principal de las radiografías torácicas durante la mayor parte de la enfermedad; después quedó como residuo visible una fina malla de espesamiento intersticial. La mejoría radiológica se rezagó, comparada con la reposición clínica.

A High-Contrast Photographic Recorder for Scintillation Counter Scanning[1]

DAVID E. KUHL, M.D., RICHARD H. CHAMBERLAIN, M.D., JOHN HALE, M.S., and ROBERT O. GORSON, M.S.

DURING THE PAST four years, in the Hospital of the University of Pennsylvania, external scintillation counter scanning has been used to provide information relative to the distribution of radioactive isotopes in patients. Attention has been centered largely on representation of the thyroid gland, detection of functioning metastases of thyroid carcinoma, and the outlining of intraperitoneal and intrapleural radioactive colloidal gold distributions.

We have been dissatisfied with the standard mechanical relay recording systems, such as those which print marks on paper to indicate the rate of counting gamma-ray activity. Recently, there have been described several recording devices which attempt to provide better representation of radioactive distributions (1–4). While differing in construction, these instruments are alike in that, with constant scanner speed, the spacing of marks produced on paper or film is proportional to the time required to accumulate a pre-set number of counts. Such a recorder will outline an area whose count rate differs several-fold from the count rate of its surroundings. With smaller differences, however, the change in spacing is not sufficient to be noticed, and the area of activity may be overlooked.

Because of this, it was felt that a photographic method of recording might be advantageously employed for converting count rate data into contrasting visual images. The recording system to be described here is thought to offer an improvement in the scanning technic because the method of presenting the count rate data makes possible visualization of relatively small differences in activity. A permanent record is produced and, since the film base is transparent, the recorded image may be superimposed on a roentgenogram to permit better anatomical reference of the area under study.

A block diagram of the external scanning equipment is shown in Figure 1. The scintillation counter is driven over the patient by two motors. The signal from the photomultiplier is amplified, passed through a discriminator, and counted with a scaler. A signal from the scaler drives a conventional mechanical recording system[2] and, after electronic modification, energizes the light source for the photographic recorder. The light source is enclosed with the recording film in a light-proof box.

DESIGN OF SCANNER AND RECORDER

Mechanical Apparatus: The scanner framework (Fig. 2) is suspended so that it can be positioned in height or rotated about an axis between its supporting columns. Such flexibility is desirable, since it makes possible scanning from above, below, or from the side without change in the position of the patient. This feature is particularly useful in scanning fluids which may shift within the body.

The radiation detector is a photomulti-

[1] From the Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, Penna. Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

This investigation was supported in part by a research grant (C-1984) from the National Institutes of Health, U. S. Public Health Service, an institutional grant (C-18) from the American Cancer Society, a student fellowship grant from Lederle Laboratories, and a student fellowship grant from Mr. Edward Page.

A paper based on this work received the Borden Undergraduate Research Award in Medicine at the University of Pennsylvania in April 1955.

[2] The photographic recorder is supplemented by a conventional mechanical recorder in each operation. Because of the slow response of the mechanical system, additional scaling circuits were added to provide pulses of optimum rate to this recorder.

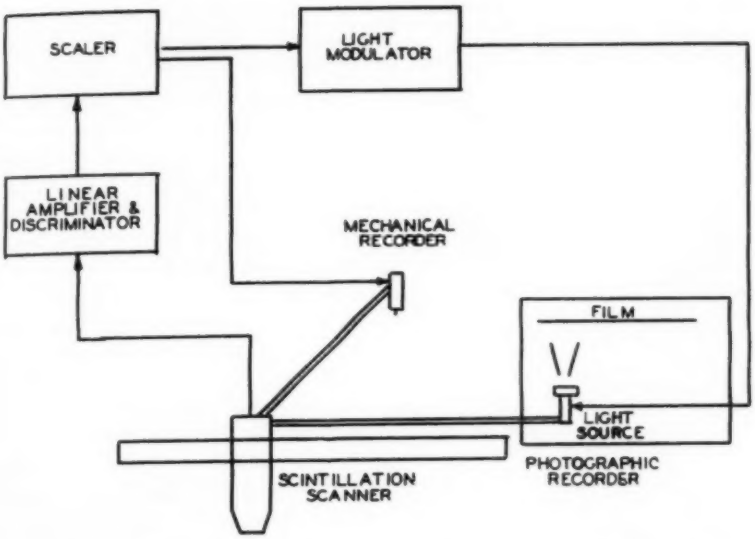


Fig. 1. Block diagram of scanner and recording system showing interconnection of component parts.

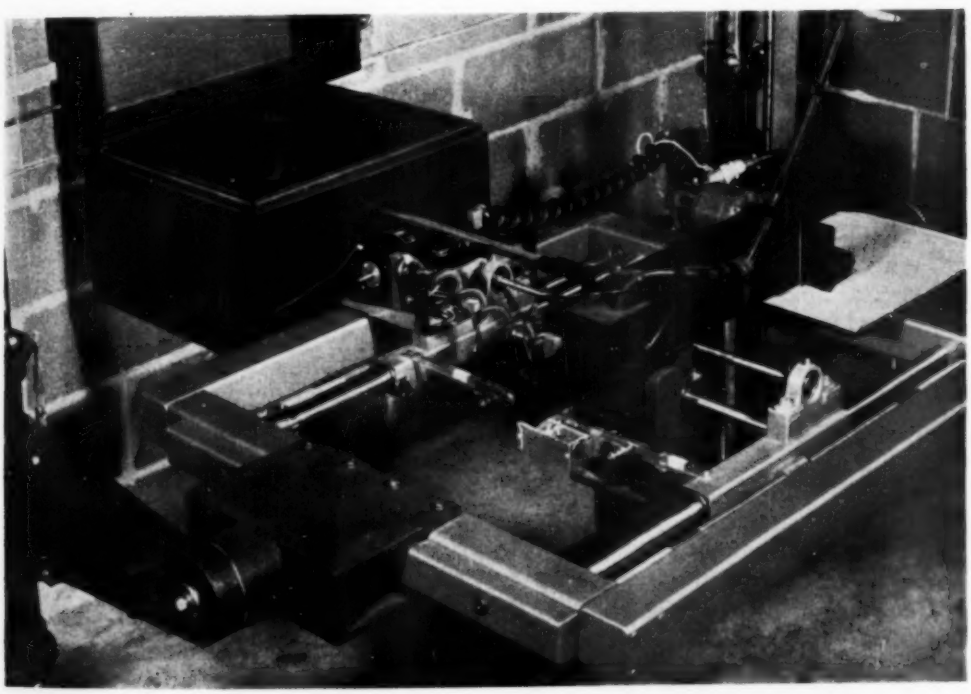


Fig. 2. Mechanical details of scanner and recorder. The framework which holds the motor drive for the scintillation detector can be positioned in height and rotated 180° between the supporting columns. The light-tight box containing the light source and the recording film is seen in the background.

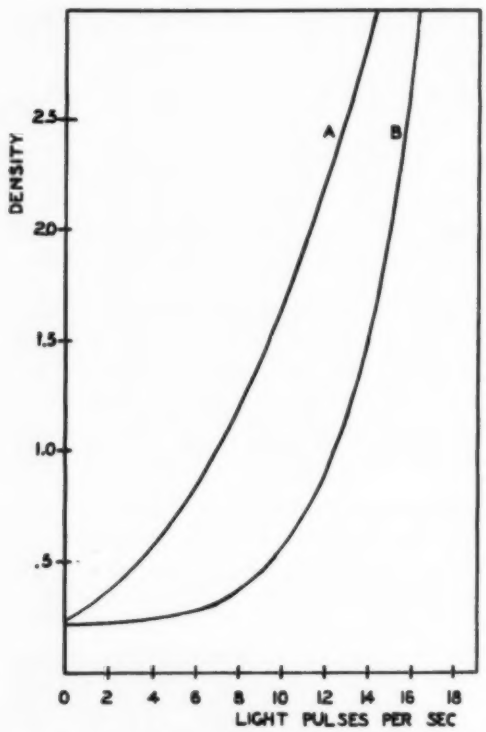


Fig. 3. Calibration curves of film recorder showing variation of recording film density with pulse frequency of the light source. The choice of Curve A or B is made by simple electronic adjustment.

plier[3] with a 1-inch cylindrical NaI (Tl) crystal housed in a lead collimator with variable apertures. One motor drives the detector back and forth across the patient at a speed which is adjustable from 0 to 2 cm. per second. A second motor advances the detector to a pre-set distance at the end of each cross sweep. This spacing can be varied from 1 to 27 mm. An area $12^1/_8 \times 13^1/_2$ in. can be scanned in a single operation.

The photographic recording system is contained in a lightproof enclosure attached to the scanner framework. The top of this unit consists of a film holder with a dark slide to protect the film from exposure when the holder is removed from the scanner. Within the enclosure, the glow tube light source moves under the film in synchronism with the scanning detector. A choice of apertures permits shaping of the light beam to correspond to different choices of vertical scan spacings.

Light Source: For the light source, a glow tube,[4] originally designed for facsimile reproduction, was chosen. The brightness of the light beam which it emits bears an essentially linear relationship to the tube current.

The light-source signal is originally obtained from scaler pulses which represent 10, 100, or 1,000 accumulated counts, as chosen by settings of a selector switch. Following amplification, these pulses trigger a one-shot multivibrator which produces pulses of either 1.0 millisecond or 0.1 millisecond duration. Following two more stages of amplification, this pulse wave form is introduced to the grid of a power tube, producing a flash of the glow tube which is in the plate circuit of the power tube.

The light pulses from the glow tube not only increase in rate but also in brightness as the count rate rises. This is because the time constant of the resistance-capacitance coupling to the power tube is relatively short (47 milliseconds) compared to the period of repetition over the useful pulse rate range (1,000 to 70 milliseconds). The magnitude of the grid signal voltage therefore depends upon the pulse repetition rate. The modulation of both the frequency and amplitude of the light output causes the film exposure to increase rapidly with respect to count rate and produces large film-density changes (high contrast) over a suitable count rate range.

INSTRUMENT CHARACTERISTICS AND APPLICATION

The characteristics of the photographic recording system are shown by the calibration curves of film density as a function of count rate (Fig. 3)[5]. Two particu-

[3] RCA 5819.

[4] Sylvania R1131C.

[5] These curves were made at a constant scanner speed of 1 cm. per second. Kodak Blue Brand film developed in Kodak Rapid Developer for 5 minutes at 68° F. was used.

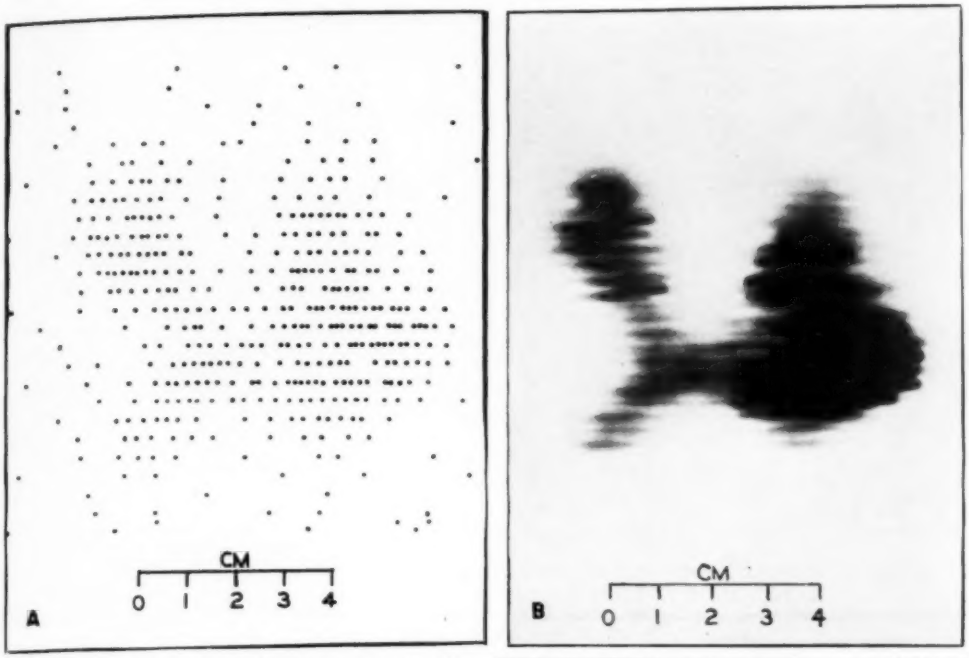
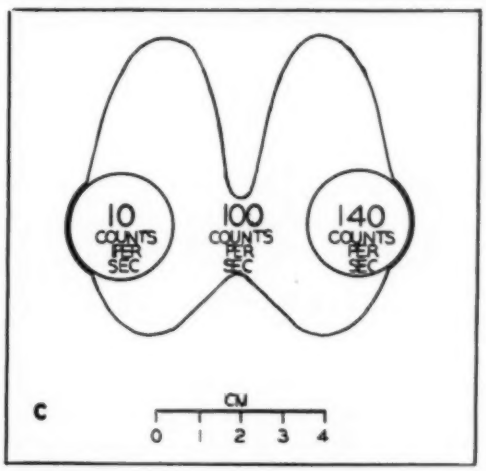


Fig. 4. Comparison of thyroid phantom scans made with mechanical relay recorder (A) and with the photographic recorder Curve A response (B). The distribution of radioactivity is shown in C. The area of decreased activity is seen in both scans, but the area of increased activity is apparent only in (B).

larly useful recorder responses are illustrated. A family of such curves, differing in average slope, may be obtained by proper choice of pulse width and power tube grid bias value.

The density change shown in Curve A is continuous from film fog level to a value of 3 over a range of 0 to 14 light pulses per second. The relative linearity of this curve permits variations in activity to be represented as proportional gradations in film blackening. A detailed image is produced which allows visualization and comparison of several closely approximated structures with small activity differences.

We have found the recorder response shown in Curve A to be most useful for studying activity distribution in the thyroid gland. A simple phantom experiment demonstrates how a thyroid gland survey could be improved with the photographic recording system.



A model was constructed to represent the thyroid gland with two small bilateral nodules (Fig. 4C). Different amounts of I^{131} were distributed in this phantom so that 100 counts per second could be recorded over the thyroid lobes, 10 counts per second over one nodule, and 140 counts per second over the other. The simulated thyroid parenchyma presented a count rate ten times that of the "cold"

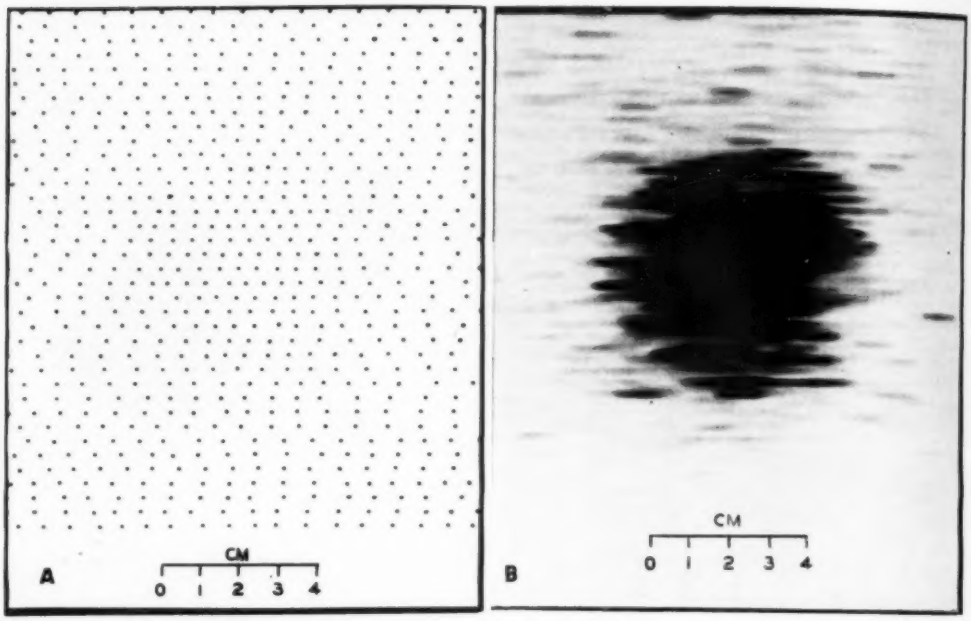
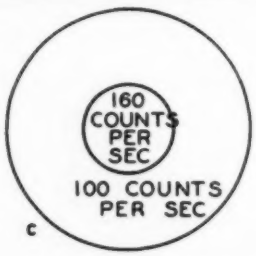


Fig. 5. Comparison of scans made from tumor phantom with mechanical relay recorder (A) and with the photographic recorder Curve B response (B). The image is more apparent in the film scan because the background count has been suppressed by utilizing a non-linear response available with the photographic recorder.



nodule, but the "hot" nodule differed from thyroid gland background by a factor of only 1.4.

Simultaneous dot and photographic scans of this model were made (Fig. 4) with the following choice of instrument settings: selector switch, 1 light pulse per 10 gamma rays detected; scan speed, 1 cm. per second; recorder response, Curve A. A comparison of the mechanical relay scan (Fig. 4A) and the film scan (Fig. 4B) obtained from this phantom shows that while the "cold" nodule is well differentiated from the gland in both scans, the "hot" nodule is clearly evident only in the film image.

An alternative recorder response is shown in Curve B of Figure 3. Below a pulse rate of 8 per second in this curve, the image density merges into the fog level and the contrast is poor. As this rate is exceeded, excellent contrast is produced: the density increases rapidly to 3 as the pulse rate increases to 16 light pulses per second.

This delay in density change can be used to advantage in situations involving the detection of a lesion which differs only slightly in activity from surrounding tissues. By adjusting the instrument so that a high background count rate falls well within the insensitive toe of the rapidly rising curve, that background is efficiently suppressed and only those areas above a certain threshold activity level will be recorded on the film.

A second experiment shows how the recorder response of Curve B can be used to suppress background and, when so applied, to demonstrate a radioactive tumor with activity only slightly greater than its surroundings.

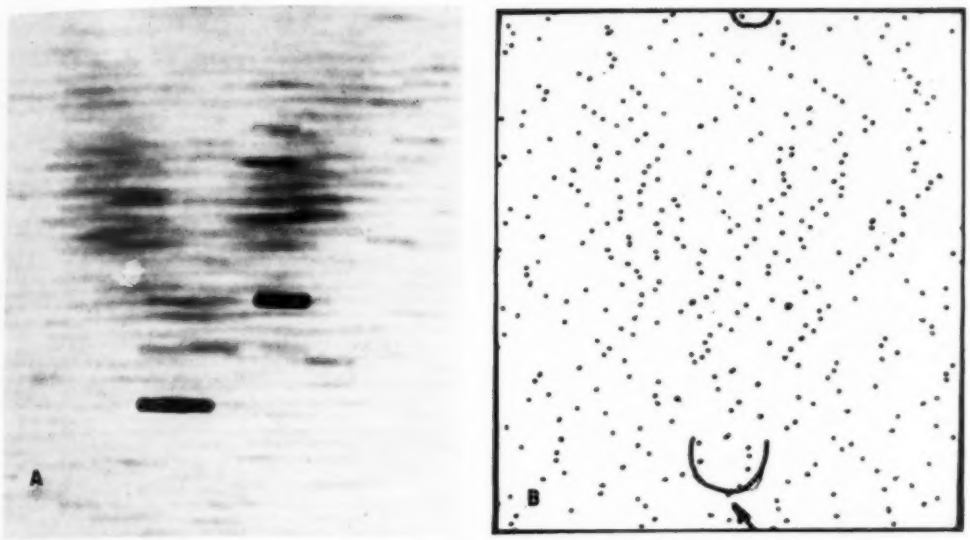


Fig. 6. Thyroid with nodule palpable between markers, twenty-four hours after 200 microcurie tracer dose of I^{131}, with 12 per cent thyroid uptake. Thyroid contours well defined on photoscan (A); poorly outlined on mechanical recording (B).

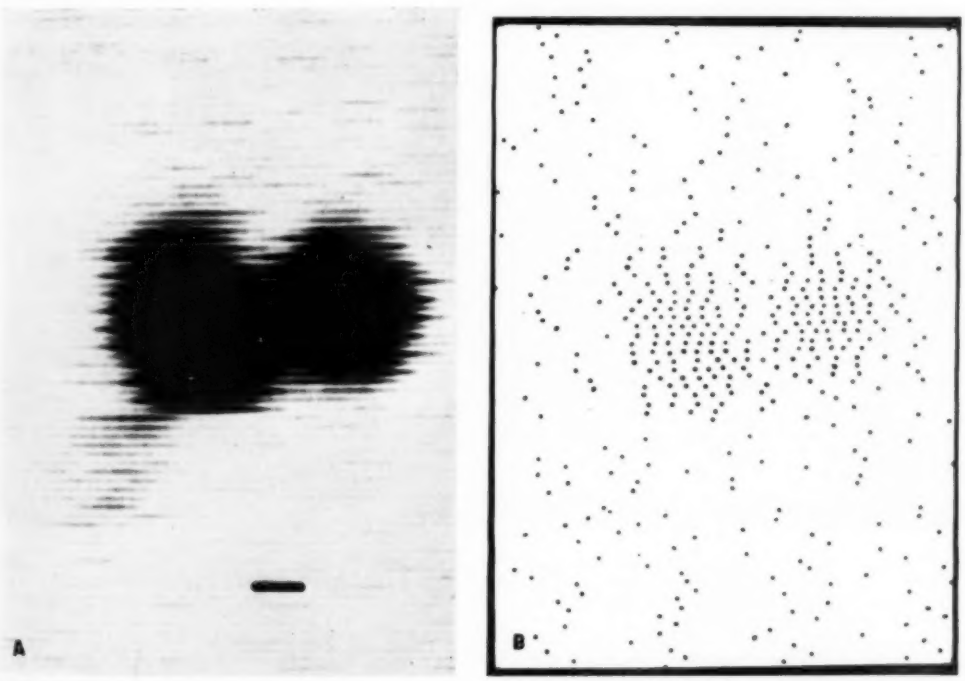


Fig. 7. Thyroid carcinoma with regional metastasis twenty-four hours after tracer dose of 500 microcuries, of I^{131} (27 per cent thyroid uptake). Photoscan (A) shows probable regional metastasis outside of residual thyroid. This is not evident on mechanical recording (B).

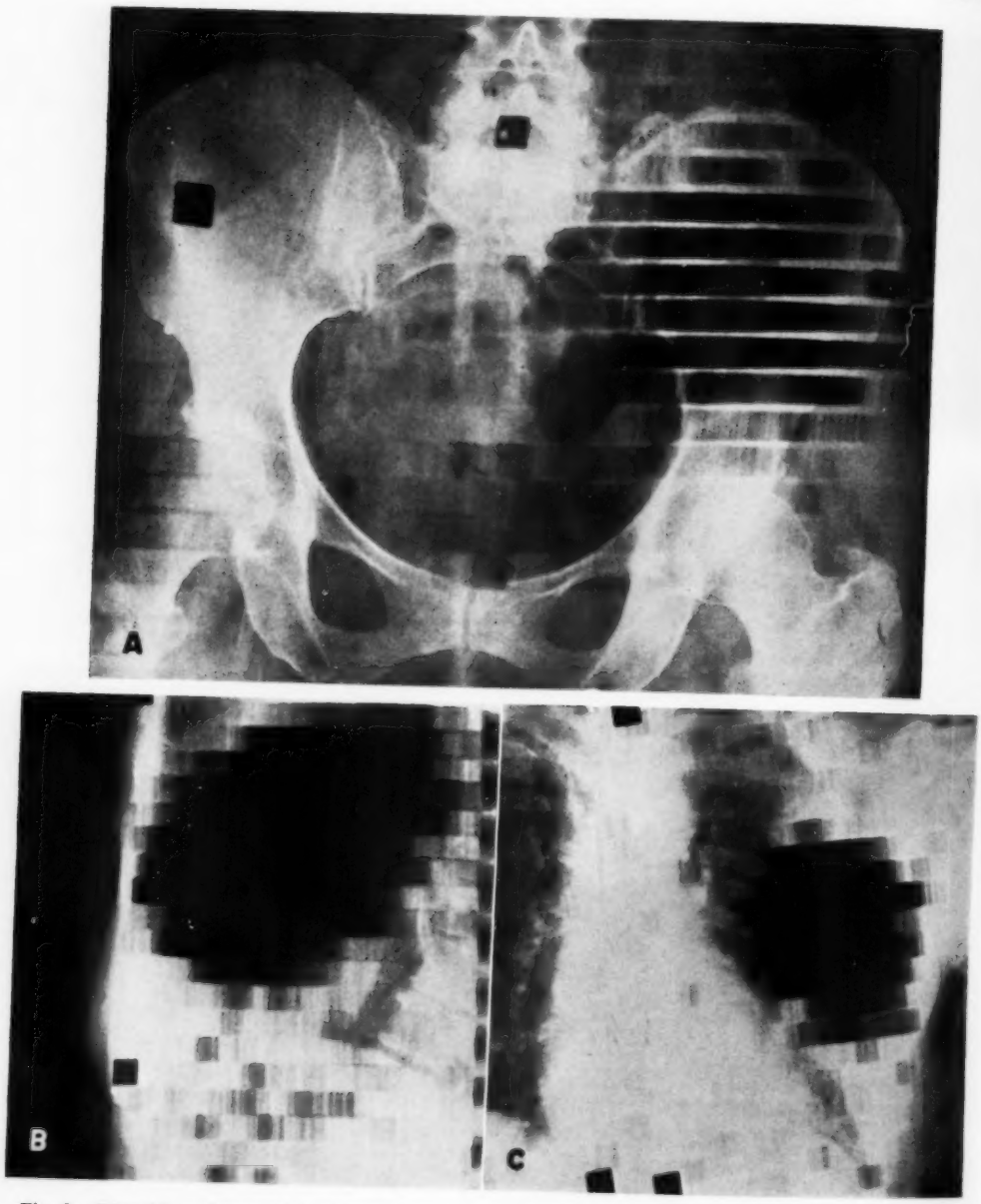


Fig. 8. Thyroid carcinoma with widespread metastases, forty-eight hours after 70 millicurie treatment dose of I^{131}. Photoscans and roentgenograms superimposed by means of registration markers. Photoscan (A) shows metastases in pelvis and femur. Metastatic lesion in left chest wall seen in lateral (B) and anteroposterior (C) photoscans of supine patient.

In this instance, a small bottle was submerged in a large volume of water. The quantities of I^{131} in the bottle and larger container were so adjusted that the rate recorded over the bottle was 160 counts per second while that over the surrounding solution was only 100 counts per second (Fig. 5C). Simultaneous dot and photographic scans were made with the recorder response set to follow Curve B, the other

instrument settings remaining as before (selector switch, 1 light pulse per 10 gamma rays detected; scan speed, 1 cm. per second). A comparison of the mechanical recorder scan (Fig. 5A) and the film scan (Fig. 5B) of this phantom shows the "tumor" to be much better demonstrated on the film.

It is frequently useful to correlate the areas of higher count rate with anatomical reference points in or on the patient. This can be done approximately by superimposing the transparent film scan on appropriate roentgenograms.

Reference marks are placed in ink on the patient's skin to define landmarks on the periphery of a scanned area. With the counter centered over each of these marks, the glow lamp is flashed to produce a corresponding dot on the film. At the completion of scanning, a lead dot is placed over each of the ink marks and, with the patient in the same position, a roentgenogram is made of the region. Careful centering of the x-ray cone on the uptake area helps to reduce distortions. The reference marks are aligned in viewing the superimposed films.

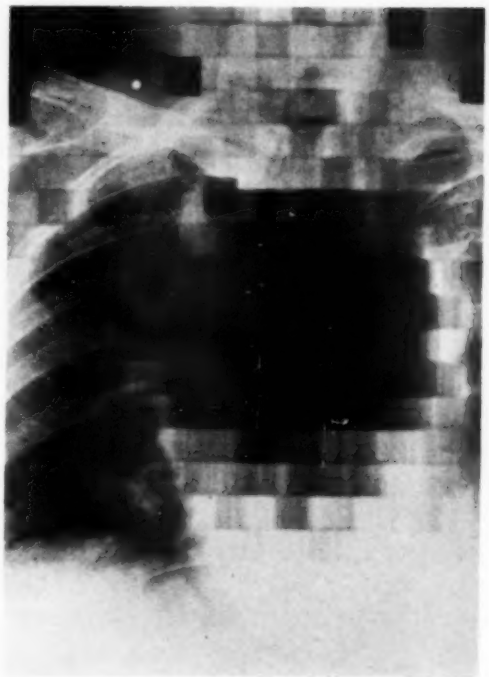


Fig. 9. Mediastinal mass in patient with carcinoma of right breast and history of previous operation for substernal thyroid. Photoscan (superimposed on roentgenogram) shows lesion to be thyroid tissue rather than metastasis from breast or other mass lesion.

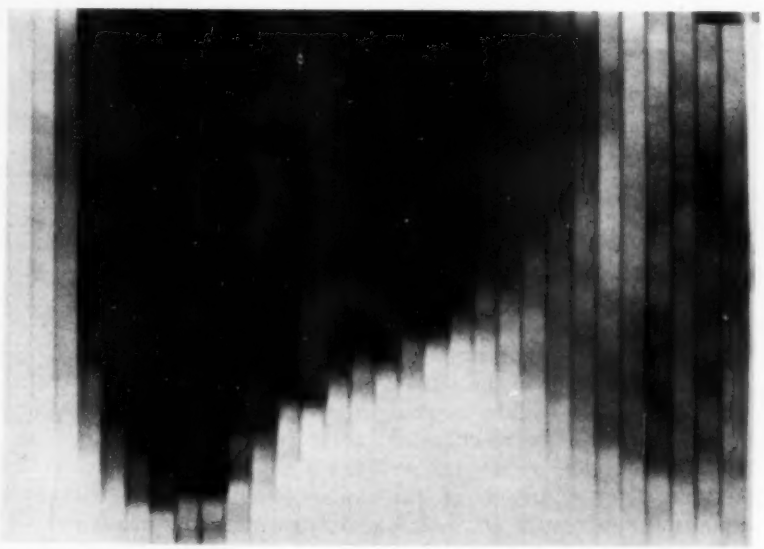


Fig. 10. Hepatosplenomegaly associated with Hodgkin's disease. Liver and spleen outlined by photoscan following intravenous administration (therapeutic) of 40 millicuries of colloidal Au^{198}.

Fig. 11. Intractable right pleural effusion due to metastatic carcinoma of breast. Photoscan following instillation of 40 millicuries colloidal Au^{198} shows good isotope distribution.

CLINICAL TRIAL

In the eight months prior to the present report, the new recorder was used in the scanning of about 100 patients. The film system was supplemented by a conventional mechanical recorder in each scanning operation in order that the progression of the scan might be observed.

The contrast intensification of the photographic system has made visible thyroid abnormalities not seen on the mechanical recording. The photoscan, on several occasions, provided a good image of the gland although the amount of iodine proved insufficient for an adequate mechanical recording (Fig. 6).

Improvement has also been evident in our scans of thyroid carcinoma metastases (Figs. 7 and 8), substernal thyroid tissue (Fig. 9), and depot sites of both intravenous (Fig. 10) and intracavitary (Figs. 11, 12) colloidal Au^{198}.

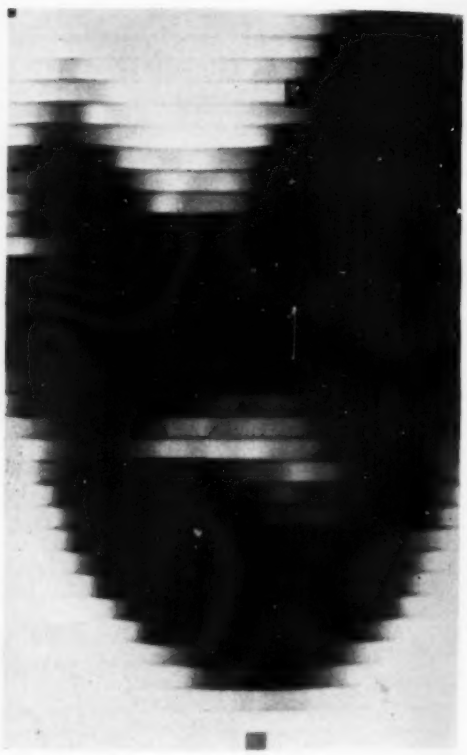


Fig. 12. Intractable ascites due to peritoneal metastases of ovarian carcinoma; 125 millicuries Au^{198} instilled. Photoscan shows fair distribution and influence of anatomical structures in abdomen.

SUMMARY

A photographic recorder is described which extends the clinical usefulness of scintillation scanning of patients who have received radioactive isotopes. High-contrast images are produced on x-ray film by a scanning light beam, the pulse frequency and pulse brightness of which increase with the count rate.

The recording method offers four principal advantages: contrast enhancement,

variability of contrast, background suppression, and accurate anatomical localization.

Clinical trial has confirmed the usefulness of the new recording system in visualization of isotope distributions in the body.

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SUMARIO

Registrador Fotográfico de Alto Contraste para el Escrutinio del Centelleo

El registrador fotográfico aquí descrito extiende el valor clínico del escrutinio del centelleo en los enfermos que han recibido isótopos radioactivos. Prodúcense imágenes de alto contraste en película roentgenológica con un haz luminoso escrutador con una frecuencia y brillantez de pulso (modulación) que aumentan con la velocidad del mismo.

El método registrador posee cuatro ventajas principales: realce del contraste, variabilidad del contraste, supresión del fondo y exactitud en la localización anatómica.

La prueba clínica ha confirmado la utilidad de este nuevo sistema registrador en la visualización de la distribución de los isótopos en el cuerpo.

DISCUSSION

John S. Laughlin, Ph.D. (Memorial Hospital, New York, N. Y.): It should be emphasized that, since the resolution of any detection device has a finite value, it is extremely difficult in mechanical recording with a solenoid printer to allow for the circle of resolution, with the result that valuable information is lost. With the photographic method described here, the overlapping of separate flashes of the light source on the photographic film can correspond to the actual finite circle of resolution. The consequence of this overlapping and accumulation on the film is that all of the information from the detecting device is recorded. The authors have also indicated that they intend to make use of pulse-height energy selection in order to minimize further the effects of scattered radiation. This is an excellent piece of work and makes the whole procedure of scanning (scintillation and otherwise) much more useful.

Harold O. Wyckoff, Ph.D. (National Bureau of Standards): Being financially minded, I would like to ask, what is the relative cost of this instrument compared to the regular commercial device?

Dr. Kuhl (*closing*): The expense of adding this photographic recorder to a standard automatic scanner would be small compared to the original investment. The electronic network necessary for modulation of the light should be no more difficult to construct than an average small "hi-fi" amplifier.

Infrapulmonary Pleural Effusion[1]

WILLIAM F. BARRY, Jr., M.D.[2]

THE DEMONSTRATION of small amounts of pleural effusion has been a difficult problem. The typical "S" line of Ellis is now an accepted finding in physical diagnosis and in routine chest x-ray projections. It is also a well established fact that routine roentgenograms may fail to reveal as much as 500 ml. of pleural fluid. This occult fluid may well be concealed in the infrapulmonary space, the portion of the pleural cavity between the diaphragm and the inferior surface of the lung.

Rigler (6) was probably the first radiologist to employ special positions for the diagnosis of small pleural effusions. By use of the lateral decubitus position, with a horizontal x-ray beam he was able to show minimal quantities of fluid. He reported 5 cases in which fluid was demonstrated in this position, while the upright postero-anterior projection presented a normal appearance. In 3 other cases, lateral decubitus films established a diagnosis of pleural effusion which had been equivocal on routine views.

Between 1931 and 1936, several isolated cases of infrapulmonary effusion were reported. In view of the fact that many of these collections presented a flat upper surface, Korol and Scott (4) suggested that they were actually the result of hydropneumothorax with very small air-fluid levels. This theory has never been substantiated.

In 1936, Rigler (7) described certain groups of cases in which pleural effusions assumed an atypical distribution. Among the factors responsible for the position of fluid in the pleural cavity, he mentioned the retractile power of the lung and the surface tension of the fluid. Included in his paper were illustrations of 2 cases secondary to lipoid nephrosis.

From 1936 to 1950, several isolated instances of infrapulmonary effusion were reported. In the latter year, Rothstein and Landis (8) presented a series of 12 cases. In 1951, Hessén (3) published a monograph in which he described 12 cases of infrapulmonary effusion associated with known disease of varying types, 12 conclusive cases in apparently healthy individuals, and 21 cases in post-partum women. In 1954 Friedman (2) reported 17 cases and stated that 20 more were seen after submission of his paper for publication.

The present study concerns 7 patients with infrapulmonary effusion seen in the x-ray department of a 150-bed general hospital from February 1953 through January 1954; in the same period 45 patients with unmistakable signs of pleural effusion were encountered. Thus, of 52 cases of effusion, 7 (approximately 13 per cent) were infrapulmonary in location. In this same period 2 "false positives" were encountered, in which an infrapulmonary collection was suspected but not confirmed by special views.

The following are presented as examples:

CASE I: G. A. R., a 58-year-old white male, was admitted on Jan. 6, 1954, with a history of epigastric distress radiating to both arms, occurring two months previously. This was followed by slight exertional dyspnea, mild nocturnal dyspnea, and slight orthopnea. On admission, the blood pressure was 110/70, and the pulse regular and even. There was slight cardiac enlargement with a loud Grade 3 systolic murmur at the apex. The routine chest projection revealed an increase in the vascular markings in the perihilar areas (Fig. 1). The left diaphragm and gastric air bubble were separated by a band of homogeneous density. A film taken with the horizontal beam, in the left lateral decubitus position (Fig. 2), demonstrated a free pleural effusion along the left lateral chest wall. The patient was digitalized and given mercurial diuretics, following which

[1] From the Chesapeake and Ohio Hospital, Clifton Forge, Va. Accepted for publication in April 1955.

[2] At present Acting Chief, Department of Radiology, VA Hospital, Durham, N. C., and Assistant Professor of Radiology, Duke University.

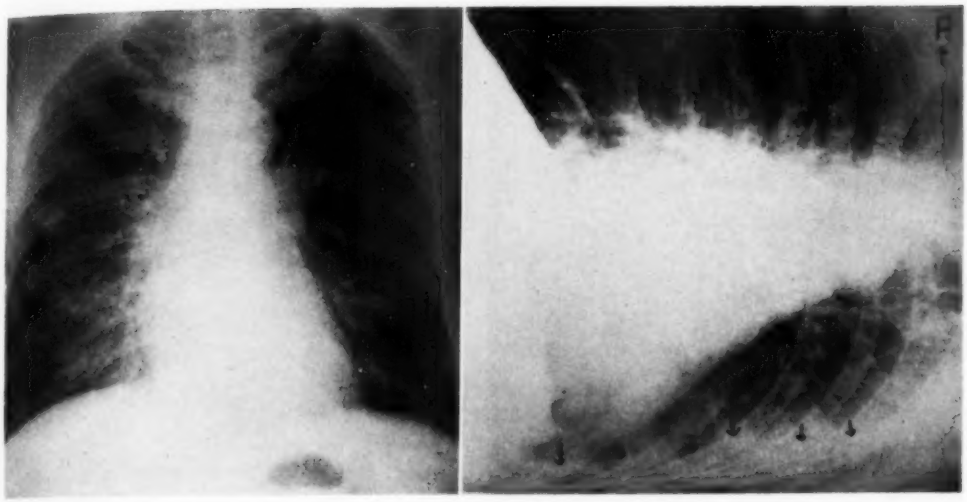

Fig. 1. Case I. Routine postero-anterior projection. Note separation of gastric bubble from what appears to be the left diaphragm.
Fig. 2. Case I. Left lateral decubitus projection. Note the fluid level along the left lateral chest wall.

he lost about 8 pounds. A subsequent chest roentgenogram (Fig. 3) showed the left diaphragm to be normal in position and thickness.

CASE II: M. M., a 62-year-old white female, was admitted on July 15, 1953, with a seven-year history of irregular heart beat. She had recently experienced exertional left chest pain. Blood pressure on admission was 160/100. The heart rate was rapid and irregular, with a harsh systolic murmur and a loud pericardial friction rub. The electrocardiogram showed low voltage and auricular fibrillation. A routine chest film, taken on July 17, disclosed fairly obvious pleural effusion in the right chest cavity (Fig. 4). Separation of what appeared to be the left diaphragm and the gastric bubble was also evident. A second film, in the left lateral decubitus position, disclosed a definite fluid level along the lateral chest wall even though the patient was slightly rotated (Fig. 5). The following day 400 ml. of straw-colored fluid were removed from the left chest cavity by thoracentesis. The final diagnosis was pericardial effusion and bilateral pleural effusion, probably tuberculous in origin.

The last case to be described (Case III) was seen after this series was collected and is not included in the statistical analysis. In this instance, an alert clinician suspected fluid, although the routine chest film was within normal limits.

CASE III: M. E. N., a 27-year-old white male, was admitted on July 6, 1954, with a five-day history of swelling about the eyes and a three-day history of

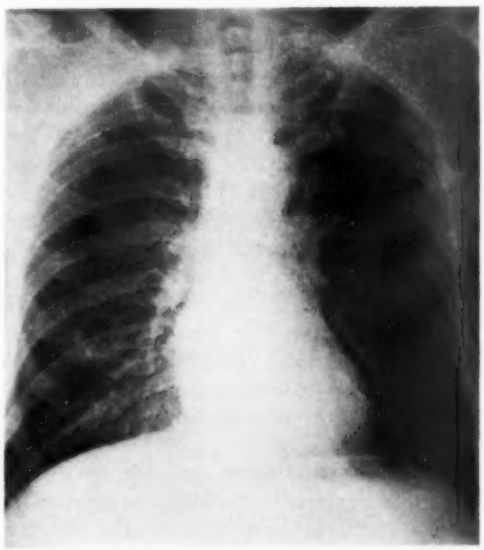

Fig. 3. Case I. Routine postero-anterior projection after digitalization and diuresis. The gastric bubble and thin diaphragm are evident.

nocturnal swelling of the feet. He had also experienced headaches and malaise. There was a history of "Bright's disease" at eight years of age, with recurrent episodes of sore throat since that time. A routine chest film on admission was within normal limits. The clinician suspected pleural effusion on the basis of the physical findings. Lateral decubitus films demonstrated bilateral infrapulmonary effusion.

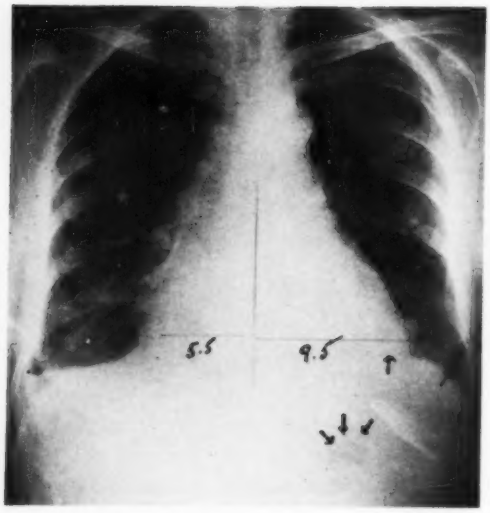

Fig. 4. Case II. Routine postero-anterior projection, with the usual configuration of fluid in the right chest cavity. On the left side, the separation of the gastric bubble from what appears to be the left diaphragm is indicated by arrows.

DISCUSSION

Minimal pleural effusions probably occur much more frequently than routine upright postero-anterior projections of the chest would indicate. That infrapulmonary collections are probably far more numerous than indicated by reports in the literature is evidenced by the fact that 7 cases were seen in a 150-bed general hospital in a period of one year. In the six months following this series, 3 additional cases were found. The frequency of discovery of this process is directly dependent on the index of suspicion of the radiologist and clinician.

It is probably more difficult to detect infrapulmonary collections in the right chest cavity than in the left, since the density of the liver is the same as that of fluid. Hessén diagrammed changes in the contour of the diaphragm which he believed were indicative of infrapulmonary effusions. With his criteria and a high index of suspicion in regard to the cause of an elevated right diaphragm, more infrapulmonary collections will be discovered.

On the left side, elevation of the diaphragm and separation of what appears to be the diaphragm and the gastric bubble should arouse suspicion of an effusion. Inflation of the stomach with carbonated beverage aids in delineation of the lower margin of the diaphragm, demonstrating the relative thickness of the fluid layer.

Several signs which may help to confirm the presence of an infrapulmonary collection have been described. Fluid waves may be observed fluoroscopically along the upper border of the "elevated diaphragm." These are propagated by the heart motion and proceed laterally from the mesial portion of the chest cavity. Under fluoroscopic control, when the patient leans to the affected side, the fluid may be directed into the lateral costophrenic sulcus. Pneumoperitoneum will delineate the lower surface of the diaphragm and thus demonstrate the thickness of the layer of fluid. In the lateral decubitus position employed by Rigler and Hessén, the fluid flows along the dependent lateral chest wall. We believe this method of demonstrating infrapulmonary collections to be the least difficult and the most productive of reliable results.

Fig. 5. Case II. Left lateral decubitus projection, with the fluid level along the left lateral chest wall outlined by arrows.

As suggested by Friedman and Hessén, all pleural effusions probably begin as infrapulmonary collections. Gravity

tends to "pull" the fluid to the most dependent portion of the chest cavity, the posterior and lateral sulci. Capillary attraction can then conceivably "draw" the fluid between the lung and the diaphragm. As more fluid accumulates in this space, it eventually "spills over" to assume the typical configuration.

If either leaf of the diaphragm appears to be more elevated than the other an infrapulmonary collection is suspected. If both sides are equally elevated, however, as in Case III, the possibility of bilateral infrapulmonary collections is usually not considered. An alert clinician may then be the first to suspect pleural effusion.

CONCLUSION

Infrapulmonary collections of fluid are more frequent than the number of reports in the literature would indicate. They are best demonstrated with the patient in the lateral decubitus position, with a horizontal x-ray beam.

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SUMARIO

Derrame Pleural Infrapulmonar

Preséntanse 3 historias clínicas de derrame pleural infrapulmonar, representando los casos encontrados en un hospital de 150 camas en el período de un año, durante el cual se observó un total de 52 casos de derrame pleural. Parece que la dolencia ocurre más frecuentemente de lo indicado por el número de comunicaciones en la literatura. El A. cree que el examen en la posición de decúbito lateral, con un haz horizontal de rayos X, constituye el medio menos difícil y más ventajoso para el descubrimiento roentgenológico del estado.

Hemochromatosis with Diabetes, Associated with Cystitis Emphysematosa[1]

HERBERT R. ZATZKIN, M.D.[2]

GASEOUS INFILTRATION of the wall of the urinary bladder, cystitis emphysematosa, is recognized rarely at autopsy and even more infrequently during life. Hemochromatosis, or heavy deposits of iron pigment in liver cells, has a reported autopsy incidence of less than 0.1 per cent and is seldom discovered before death. To encounter both entities during life in a single individual is indeed unusual. In the case to be presented here, roentgen observations facilitated recognition of each condition.

CASE REPORT

A 69-year-old white male was admitted to the Nassau County Public General Hospital (Meadowbrook Hospital), with symptoms of hematuria and frequency, reported to be of several years duration. The past history included enucleation of the left eye for glaucoma, with progressively failing vision in the remaining eye. The patient was pale and cachectic, with an enlarged non-tender liver. The abdomen was distended with fluid and the prostate was enlarged.

The blood-sugar level ranged from 300 to 500 mg. per 100 ml. and the urine was consistently positive for glucose and traces of acetone. The non-protein nitrogen was within normal limits. Impairment of liver function was indicated by prolonged prothrombin time, a three-plus cephalin flocculation, an elevated thymol turbidity, icteric index, and alkaline phosphatase, and a hypoalbuminemia.

An intravenous pyelogram showed normal excretion of the medium. On the scout film of the abdomen, the liver shadow was unusually radiopaque, and a liver biopsy was advised (Fig. 1). A repeat abdominal film disclosed gas outlining the urinary bladder, believed to be located in the interstitial bladder tissues (Fig. 2). Another film, one week later, demonstrated complete disappearance of the gas.

Repeated paracenteses were performed, with removal of large quantities of clear fluid, which were interpreted, on cell block, as acute inflammatory exudate. Edema of the leg developed, and the patient's general condition rapidly deteriorated. His diabetes could not be controlled; he became disoriented, and died six weeks after admission.

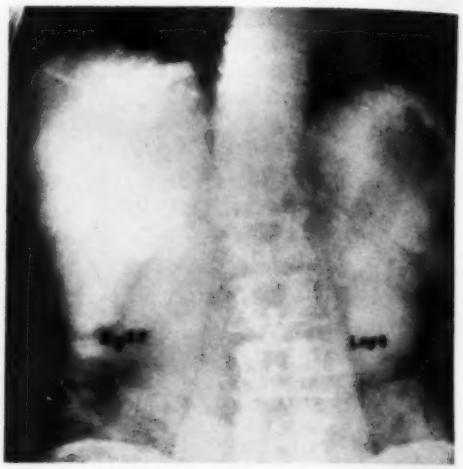

Fig. 1. Abdominal scout film showing liver shadow of unusual density.

A postmortem liver biopsy was performed; the pathological diagnosis was hemochromatosis.

In this case, clinical attention was primarily focused on the genitourinary complaints. A cystotomy was planned, and the preoperative work-up disclosed the diabetic state, which failed to respond to conventional therapy. The cystic emphysematosa was considered to be an unusual complication of the diabetes. The radiopacity of the liver suggested the possibility of a disturbance in iron pigment metabolism, and a biopsy was recommended. The true nature of the diabetic and cirrhotic state was confirmed after death, when the pathological examination revealed the underlying hemochromatosis.

HEMOCHROMATOSIS

Disturbances in pigment metabolism manifest themselves as abnormal accumulations of (*a*) lipochromes, (*b*) melanin, and (*c*) hemoglobin derivatives (1). These substances are deposited in various tissues

[1] From Meadowbrook Hospital, Nassau County Public General Hospital, Hempstead, N. Y. Accepted for publication in April 1955.

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and organs, producing disorders associated with certain symptom complexes. The hemoglobin derivatives may produce hemosiderosis and hemochromatosis. Of the two, hemosiderosis is better understood; it occurs with excessive deposition of hemosiderin in organs as a result of massive breakdown of blood, as in some of the anemias, chronic congestion, or Banti's disease.

Hemochromatosis represents a rare disturbance of iron pigment metabolism of unknown etiology, occurring usually in males past middle age (3). The unequal sex incidence may be due to the fact that the male does not lose hemoglobin, as does the female, through menstruation and pregnancy. Excessive deposits of hemosiderin and melanin are found in the skin and in the viscera, particularly the liver and pancreas (1). In the latter organs, associated fibrosis may result in interference with function, and cirrhosis and diabetes may occur. Involvement in the thyroid and adrenals, which is less marked, may further alter physiologic function, with the adrenal involvement possibly accounting for the abnormal melanin deposits associated with this condition. Attempts to incriminate heavy metal intoxication as a causative factor have not been successful. Under ordinary circumstances, a mucosal block prevents excessive iron absorption (3). In idiopathic hemochromatosis, such a block is ineffective and, over many years, a surplus of iron accumulates. Exogenous hemochromatosis has been observed following repeated transfusions. The subsequent diabetes, usually mild in degree, may be refractory to treatment, probably as a result of associated liver damage. Cirrhosis may be sufficiently extensive to give rise to ascites, with bleeding from esophageal varices. Carcinoma of the liver has been a terminal complication in 7 per cent of reported cases.

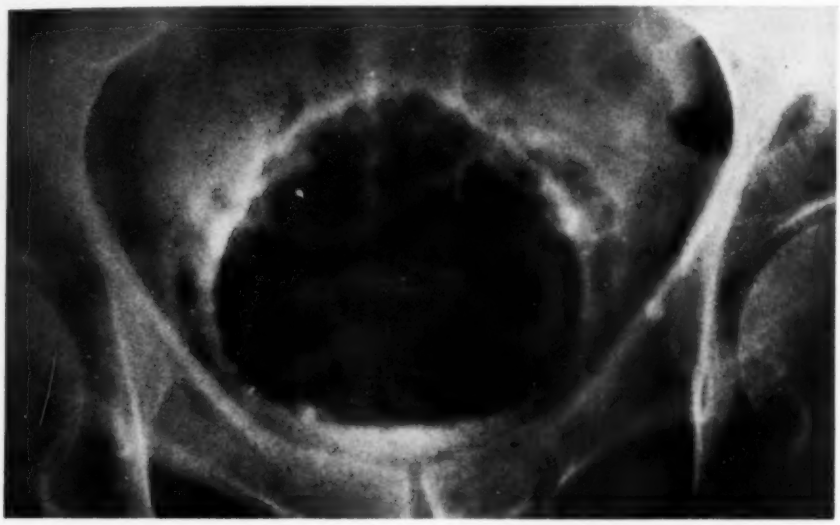

Fig. 2. Interstitial emphysema of urinary bladder. Note crescent of gas vesicles in the subserosal tissues.

On the rare occasions when a liver shadow of uncommonly great density is encountered radiologically, the first suspicion is that hepatolienography has been previously carried out by the intravenous administration of Thorotrast. This procedure is now fully discredited; with more modern methods liver density is only of fleeting duration. Iron pigment, deposited in great quantities in liver substance, can measurably increase radiopacity of the entire organ. If the prior use of Thoro-

trast can be excluded, hemochromatosis then becomes a logical explanation.

CYSTITIS EMPHYSEMATOSA

Cystitis emphysematosa is an inflammatory condition of the urinary bladder associated with gas vesicles in the tissues (6). Of the 52 cases reported in the literature, 20 were diagnosed during life. It is believed that organisms of the *Bacillus coli* group, or, occasionally, an anaerobe such as *B. welchii*, may be responsible. These organisms either invade the bladder wall by way of the blood stream or through lesions of the epithelium. The incidence of diabetes mellitus in cystitis emphysematosa is high. The elevated glucose content of the blood is considered a favorable medium for bacterial growth, favoring diffusion of the glucose into the lymph and the tissues. Histologic studies of an individual bladder show evidence of acute or chronic inflammatory changes, with hemorrhagic areas between the vesicles of gas. The bladder wall is thickened and edematous. The vesicles may be situated in the mucosa or the submucosa, or gas may infiltrate the entire wall. The vesicles have no epithelial lining, and the degree of leukocytic infiltration indicates the acuteness or chronicity of the process.

Infiltration of the bladder wall by gas produces a characteristic roentgenographic appearance. Its evanescent character should be kept in mind (2); failure to demonstrate the gas in a subsequent examination should not confuse the examiner, but rather should aid in establishing the diagnosis.

In the present case, the association of roentgen findings of unusual liver density with emphysema of the urinary bladder wall, in a patient in whom clinical and laboratory tests showed cirrhosis and diabetes mellitus, made it possible to diagnose two rather rare conditions.

SUMMARY

The co-existence of two rare conditions, cystitis emphysematosa and hemochromatosis, in the same patient, diagnosed prior to death, is reported and discussed.

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SUMARIO

Hemocromatosis con Diabetes, Asociada con Cistitis Enfisematosa

Descríbense dos dolencias raras observadas en el mismo enfermo, a saber, hemocromatosis asociada con diabetes y cistitis enfisematosa. El cuadro roentgenológico de inusitada densidad del hígado con enfisema de la pared de la vejiga urinaria, asociado esto a hallazgos clínicos y de laboratorio de cirrosis y diabetes azucarada, permitió hacer el diagnóstico antes de la muerte.

Advantages and Limitations of the 0.3-mm. Focal Spot Tube for Magnification and Other Technics[1]

MARTIN S. ABEL, M.D.

DURING THE past several years a number of reports have attested to the value of the ultra-fine focal spot in diagnostic radiology. The technics are difficult, however, and still not in general use (1–5). In the course of four years experience with 0.3-mm. focal spot tubes we have had occasion to analyze the factors involved and adapt technics for everyday clinical use.

THEORETICAL AND EXPERIMENTAL EVALUATION

The size of the focal spot affects radiographic sharpness in so far as it directly affects penumbra size. Blurring due to this factor is determined by the relative sizes of the penumbra and the radiographic image.

With decrease of the focal spot-object distance and/or increase of the object-film distance, both radiographic image and penumbra are magnified, but not in the same degree. The size of the penumbra is determined only by the relative distances involved and the focal spot size, and is independent of the size of object. With magnification, the penumbra size increases more rapidly than the image size. The practical limit to useful magnification is a little over three times, beyond which finer bony detail is lost.

Figure 1 shows the relative sizes of images and penumbrae with 0.3-mm. and 1.0-mm. focal spots, with magnifications up to three times. It is evident in this example that relative penumbra sizes with the ultra-fine focal spot are smaller with magnification than with the larger focal spot without magnification. Magnification is obviously impractical with a 1.0-mm. focal spot or larger.

It is also clear that, regardless of focal spot size, the relative penumbra size is

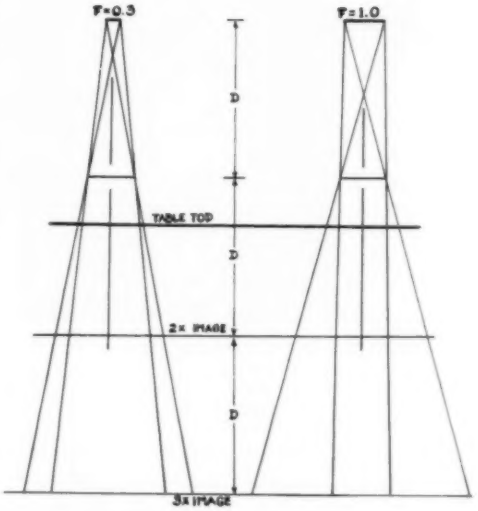

Fig. 1. Relationships of focal spot size and penumbra size with relative unsharpness of radiograph image. With a 1.0-mm focal spot and a film at the table top the penumbra is quite significant for parts of a patient some distance from the table. In the illustration above, the penumbra with the 1.0-mm. focal spot at the table top is seen to be about the same size as that with the 0.3-mm. focal spot at 2× magnification. The unsharpness with the 0.3-mm. focal spot at both 2× and 3× is less than that with the 1.0-mm. focal spot without magnification, since the overall magnification in these cases makes the penumbrae relatively less significant. Magnification with the 1.0-mm. focal spot is obviously impractical because of the relatively huge penumbra.

minimum with the least possible degree of magnification. In our experience, however, the maximum radiographic detail is obtained with magnifications of about 1 1/4 to 2×. We feel that the smaller degree of magnification is useful in non-screen examinations in bypassing the limiting factor of grain size of the film emulsion, and in helping minimize scattered radiation. The 2× magnification is needed to bypass effectively the limiting factor of the larger grain size of par-speed intensifying screens; it also minimizes a small amount of poor screen contact.

In Figure 2 is shown a fracture of the

[1] Accepted for publication in March 1955.

Fig. 2. Conventional and magnified views of the elbow. Patient, I. T., a 23-year-old laboratory technician, was injured six days prior to the date of these films. Two sets of films, on the day of injury and six days later, comprising seven views, non-screen technic, failed to establish a fracture despite strong clinical evidence. The magnified view shows a fine fracture line extending through the cortex of the radial head, without displacement of fragments.

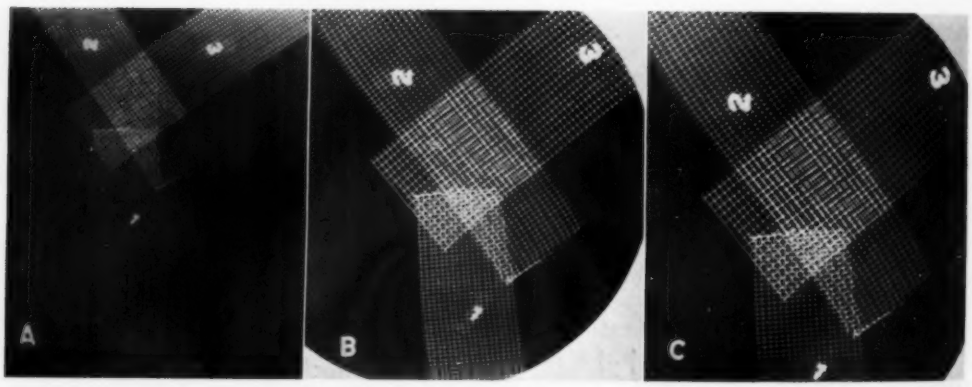

Fig. 3. Introduction of relative magnification or perspective. Three films of the same phantom at levels 1, 2 and 3, 2 1/4, 4 1/2 and 6 3/4 inches above the table top, respectively, all made with the 0.3-mm. focal spot. A. Focal spot – table top distance 40 inches, film at the table top. B. Focal spot – table top distance 20 inches; table top – film distance 20 inches. C. Focal spot – table top distance 20 inches, table top – film distance 30 inches.

In A the wires at the three levels are of much the same size and cannot be separated where they overlap. Actually the magnification at level 1 is 1.06×, and at level 3, 1.2×, a difference of 13 per cent. In B, level 1 is magnified 2.26×, and level 3, 3.02×. Here the differences in the three levels are much more apparent, but they are still difficult to separate where they overlap. In C, level 1 is magnified 2.82×, and level 3, 3.77×, and the different levels are readily distinguishable even where they overlap

Two factors are present in the development and appreciation of the relative magnification or perspective so apparent in C. First, there is a very substantial increase in the amount of relative magnification: level 3 is magnified 34 per cent more than level 1, as compared with a difference of 13 per cent in A. Secondly, the increased overall magnification makes the difference much more apparent. Actually, in B level 3 is magnified 34 per cent more than level 1, just as in C, but the fact is better appreciated with the increased magnification.

It is also to be noted that in C there is some blurring at level 3, where the magnification is 3.77×, which is over the critical value for a 1-mm. object. This blurring is minimized by the excessive contrast inherent in this metallic phantom but is readily appreciated in a bony structure.

head of the radius picked up with magnification of 1 1/4 but not seen on multiple non-magnified films. The thickness of the upper portion of the fracture line suggests that its size without magnification was less than the defining power of the film.

Of far more importance than the overall degree of magnification is the relative magnification that can be obtained. Figure 3 shows films of three strips of wire screening at levels 1, 2 and 3, at distances of 2 1/4, 4 1/2, and 6 3/4 inches, respectively, from the table top. The three exposures were made with focal spot-table top distances of 40, 20, and 20 inches, and with table top-film distances of 0, 20 and 30 inches, respectively. In the first film, where the strips overlap, it is almost impossible to differentiate the three levels. In the second film, the three levels can be distinguished, and in the last film the differential magnification or perspective of the three levels is readily appreciated. With the increased magnification, the screening at level 3 is magnified 34 per cent more than that at level 1.

This differential magnification is present in all magnification studies and, in thick parts, relationships may be sufficiently disturbed in comparison with non-magnified studies to make interpretation difficult. With familiarity and a certain amount of reorientation as to anatomical relationships, the perspective gained can be effectively utilized to differentiate superimposed structures.

In use of the fine focal spot tube, the low operating milliamperage—12 to 15 ma—is quite disadvantageous, expecially for thick parts.

The problem reduces itself to one of minimizing secondary radiation while keeping the exposure time within reasonable limits. In our experience the use of a Potter-Bucky diaphragm or grid increases exposure time excessively. Since scatter increases with the wave length of the x-radiation and the amount of tissue irradiated, the secondary radiation is initially minimized by using the highest practical kilovoltage and the smallest possible cone.

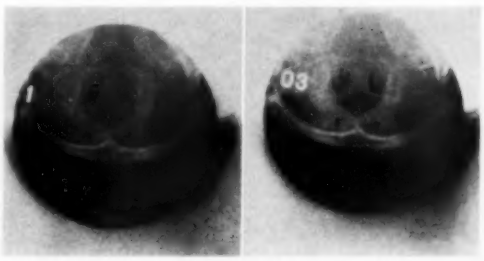

Fig. 4. Increased clarity afforded by small focal spot tube in conventional technics. Basilar skull views made with 1.0 and 0.3-mm. focal spots. The latter is demonstrably sharper. In the original films the difference is even more evident.

The effective wave length is further decreased by the routine use of 2 to 3 mm. Al filter. The secondary radiation may be considered as originating somewhere near the center of the patient, with its intensity varying according to the inverse-square law. Inasmuch as the intensity of the primary beam obeys the same law, the relative amount of secondary to primary radiation hitting the film will decrease as the patient-film and/or focal spot-patient distance is increased. The overall focal spot-film distance, however, cannot be excessive, or the exposure time will be unreasonable. In most instances focal spot-patient and patient-film distances of 20 to 24 inches have proved quite satisfactory, so that scatter is relatively dissipated before reaching the film.

CLINICAL EVALUATION

The fields of clinical usefulness of the fine focal spot tube may be divided into six somewhat interrelated categories:

1. Studies without magnification, of parts anatomically considerably removed from the film. We use the 0.3-mm. focal spot routinely for lateral views of the sternum and spot films of the base of the skull. Figure 4 illustrates the increased clarity obtained in films of the region of the foramen magnum.

2. Examinations in which circumstances make optimum routine technic impossible. Examinations made with portable apparatus are a prime example, as demonstrated by Jones (3). The ultra-fine focal

Fig. 5. Magnified basilar view of skull focused over the atlas. Patient, G. M., 46 years old, was injured in an automobile accident five months prior to date of this film, sustaining a whiplash injury to the neck. Conventional films, including open-mouth and oblique and lateral stereos were negative. Occipital headaches and pain on rotation of the head persisted, however, with varying degrees of severity. The magnified view above shows well the break in continuity of the neural arch of C-1 both anteriorly and posteriorly. Conventional films made at the same time and subsequently in the same projection were not conclusive. The deformity was not appreciated in other projections.

spot is ideal for the short distances in bedside examinations. In surgery, it becomes possible to keep the film below the operating table outside the sterile field. The tube may also be utilized where the patient cannot or should not be moved. For example, a postero-anterior film of the spine will give excellent bony detail in cases in which fracture is suspected.

3. Magnified studies where the enlargement and/or increased detail are desired *per se*. In this category lie those cases where visualization of finer bony detail or intimate structure of a lesion is desirable for proper demonstration and/or evaluation. We use 1 1/4 × magnification routinely for examination of the carpal bones. The fracture of the radial head shown in Figure 2 is another example.

4. Examinations in which differential magnification is especially utilized. As was demonstrated with the wire phantom in Figure 3, structures in planes of the body quite close together may be magnified to significantly different degrees. An appreciation of the resultant perspective is extremely helpful in separating superimposed structures. We employ the technic routinely to search for minor traumatic lesions of the cervical spine. For adequate visualization of the entire ring of C-1, we take magnified, stereoscopic basilar views of the skull. When it is necessary to free the atlas of superimposed structures, both suboccipito-mental and submental-occipital views are taken. Figure 5 is a magnified axial view of C-1 in a patient who had sustained a whiplash injury five months prior to examination. The break in continuity of the vertebra both anteriorly and posteriorly is well demonstrated. The lesion was not definitely shown in nonmagnified axial views and could not be seen at all on lateral, oblique, or open-mouth views. The obliquity of the head which helps demonstrate the lesion is due to the patient's discomfort and not a result of consciously faulty positioning. In our experience, localized tilting of the occiput on the upper cervical spine is a valuable indirect sign suggesting the possibility of bony injury of the atlas or axis.

Differential magnification may be purposely exaggerated to blur out of significance structures closest to the x-ray tube. Figures 6A and 6B are magnifications 2 and 3×, respectively, of the base of the skull. Much better detail is present in the latter. Of particular interest are the overmagnification and blurring of the mandible, allowing clearer visualization of the underlying sphenoid sinuses and upper teeth.

Occasionally differential magnification may be utilized for better visualization of overlying structures. With this technic, an anteroposterior view of the upper sternum (angled 30° to the head) will magnify the lateral borders of the sternum free of the underlying spine and give a symmetrical anteroposterior projection of the sternoclavicular joints.

5. Planigraphy. The long exposure, low milliamperage, and considerable patient plane-to-film distance employed in planigraphy are all applicable to use of the ultra-fine focal spot tube. As demonstrated by Wood (4), films of exceptional clarity are obtained.

The author has devised a method of body-section radiography with the 0.3-mm. focal spot, utilizing variable magnification for plane selectivity (6). During exposure the tube and film are moved toward each other along the same vertical axis. The selected mid-plane remains sharply defined because it is continually magnified at a fixed rate, while all other planes blur because of continually varying magnification.

6. Fluoroscopy. Because of the short focal spot-patient distance, the penumbra effect is more prominent in fluoroscopy than radiography, and the use of an 0.3-mm. focal spot fluoroscopic tube is justified to diminish this effect. Our subjective impression is one of considerably improved fluoroscopic detail with the ultra-fine focal spot.

LIMITATIONS OF MAGNIFICATION TECHNICS

The usefulness of magnification technics is limited by at least three main factors:

1. Because of the long exposures, the problems of immobilization are considerable and sometimes insurmountable. For the most part we limit the technic to bones and joints.

2. Because of the extreme coning desirable in the examination of thick parts, screening films of large areas are not practicable. Usually the technic is limited to a small area where a routine film has led to suspicion of a lesion.

3. In some instances, a lesion is best appreciated without magnification. In these cases, evaluation depends on overall

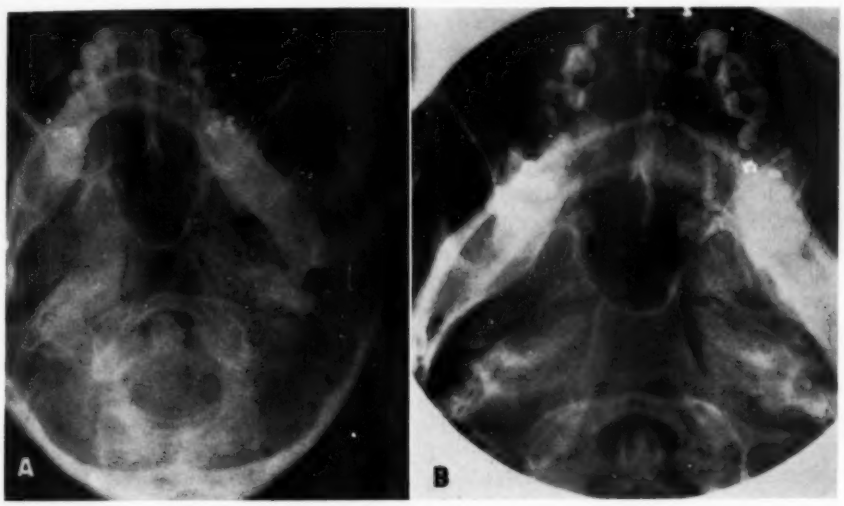

Fig. 6. Magnified views of the base of the skull. Factors: A. 24 inches from focal spot to table top, 24 inches from table top to film. B. 17 inches from focal spot to table top, 24 inches from table top to film. With the basilar skull structures about 3 1/2 inches above the table top, they are magnified about 2 1/4× in A and about 3× in B. In B, all structures closer to the tube than the base of the skull, such as the mandible, are overmagnified beyond the critical value of 3× and are blurred. Consequently in B the basilar structures are demonstrated with exceptional clarity, and the anterior structures at the same level, as for example the root canals of the maxillary teeth and the sphenoid sinuses, are clearly seen through the fuzzy outlines of the mandible. This is comparable to seeing objects clearly through a screen door close at hand, even though the screen may be quite opaque from a distance.

variations of density and structure. With magnification, the forest may not be seen for the trees.

SUMMARY AND CONCLUSIONS

With use of the 0.3-mm. focal spot there is a marked reduction in x-ray penumbra formation, making possible direct magnification with preservation of detail. In comparison with the larger conventional focal spots, better detail can be obtained in both routine radiographic and magnification technics, as well as in fluoroscopy. Six categories of clinical usefulness are outlined.

Because of the low operating milliamperage of the ultra-fine focal spot tube, exposures are long and technics are difficult and somewhat limited by mechanical factors.

Clinically, we believe the maximum usefulness of the very fine focal spot tube lies in magnified radiography of areas difficult to visualize because of superimposed structures. Variable magnification of these structures introduces a factor of perspective which is of great diagnostic value. The variable magnification can be purposely exaggerated in some instances to increase detail and sharpness at desired levels.

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SUMARIO

Ventajas y Limitaciones del Tubo de Punto Focal de 0.3 Mm. para Aumento y Otras Técnica

Con el uso del foco en punto de 0.3 mm., se obtiene una notable disminución de la formación de penumbra de rayos X, permitiendo esto el aumento directo con la conservación de los detalles. Comparado con los focos más grandes en uso corriente, permite obtener mejores detalles tanto en la técnica corriente de radiografía como en la de aumento, e igualmente en la fluoroscopia. Bosquéjanse seis clases de utilidad clínica.

Debido al bajo miliamperaje de funcionamiento del tubo de foco ultrafino, las exposiciones son largas y las técnicas difíciles y algo limitadas por factores mecánicos.

Clínicamente, parece que la mayor utilidad del tubo de punto focal muy fino radica en la radiografía ampliada de zonas que es difícil visualizar por tener otros órganos sobrepuestos. El aumento variable de éstos introduce un factor de perspectiva que es de mucho valor diagnóstico. Este aumento variable puede exagerarse ex profeso en algunos casos para acrecentar los pormenores y la delineación a ciertos niveles convenientes.

An Orthometric Radiograph for Obstetrical Roentgenometry[1]

GERHART S. SCHWARZ, M.D.

IN ROENTGEN PELVIMETRY, correction of the sagittal dimensions of the maternal pelvis and of the fetal skull for false magnification has never been a problem. It is achieved without major difficulty with the aid of a graduated metal marker placed in the anal fold. This marker is enlarged by the diverging x-rays to approximately the same degree as the anteroposterior pelvic diameters on the same radiograph, and from its image on a lateral view a reasonably accurate correction can be derived.

For correction of transverse pelvic dimensions, on the other hand, no simple solution exists. The parallax method has heretofore been regarded as most accurate but has not gained general acceptance. Technics employing metal markers are inaccurate when applied to the correction of transverse dimensions and results must be considered as approximate only.

The purpose of this communication is to describe a simple method which permits roentgenometry of transverse pelvic dimensions with an accuracy within a fraction of a millimeter, yet requires no mathematical computation or auxiliary correction devices such as false centimeter rulers, slide rules, charts, graphs, or tables. The procedure is applicable to any type of radiographic machine.

PREPARATORY CLINICAL INVESTIGATION

A study was made of 350 consecutive roentgen cephalopelvimetries performed at or near term on ward patients of the Sloane Hospital for Women (New York), all of whom were considered by the referring obstetrician to have borderline cephalopelvic disproportion. The measurements were obtained by the Ball (4) method and correlated with the obstetrical outcome. It could readily be seen that, with transverse pelvic diameters smaller than 8 cm. or larger than 12 cm., accurate mensuration was not essential. Diameters less than 8 cm. were so obviously below normal limits that accurate measurements were not necessary. Diameters in excess of 12 cm. never constituted an obstacle and required no further clinical consideration. The greatest need for accuracy, in respect to transverse dimensions, was found to lie in measurement of the bispinous diameter with a length in the neighborhood of 10 cm., for it is this diameter which is the most reliable (though not adequate) criterion of mid-pelvic disproportion. Statistically, the accurate measurement of the bispinous diameter was found to rank second in importance only to measurement of the anteroposterior diameter of the inlet. Since most obstetricians regard disproportion at the midpelvis as more dangerous than disproportion at the inlet, accurate measurement of the bispinous diameter is perhaps clinically of the greatest importance.

TECHNICAL SOLUTION OF THE PROBLEM

In view of the preceding considerations, a method for obtaining a radiograph on which all transverse dimensions appear in their true or nearly true size was developed. It was named "orthometric radiography," and its product the "orthometric view."

The patient is placed supine on the x-ray table, the buttocks resting on a cassette with a built-in cross-hatched 7 : 1 grid (table-top technic).[2] The back is slightly arched by a pillow supporting the dorsal spine. A cone with a rectangular window is attached to the x-ray tube so as to cover an area of approximately 10 × 20 cm.

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[1] From the Department of Radiology of the College of Physicians and Surgeons of Columbia University, and the Radiological Service of the Presbyterian Hospital, New York. Submitted to the Sixth Schleussner Roentgen Prize Competition. Accepted for publication in April 1955.

[2] For Bucky grid technic see page 755.

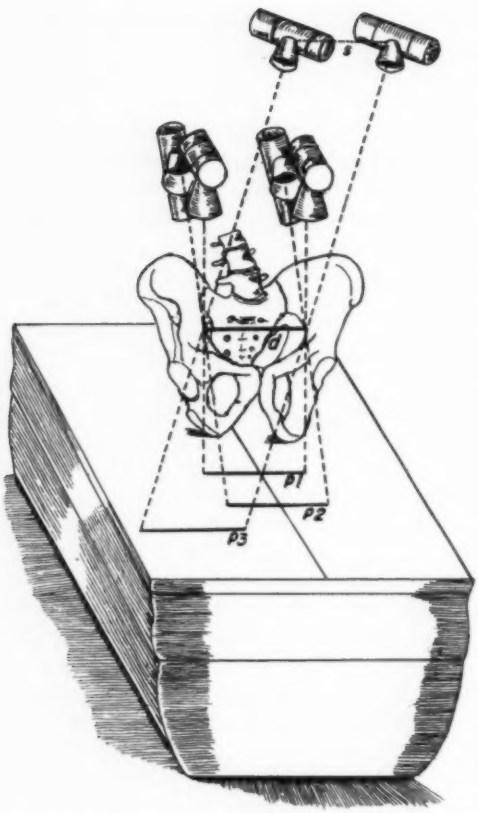


Fig. 1. The perpendicular orthometric projection (p_1) of the pelvic diameter (d), the oblique (p_2) and the double oblique projection (p_3) are equal in length provided the tube shift (s) is likewise equal in length to d. According to the geometrical theorem that parallel lines between parallel lines remain equal, a true orthometric view is thus obtained, regardless of centering or angulation. For the sake of clarity only, the tube shift for projection p_3 is shown as a dotted line (s), but the drawing is based on a tube shift of equal length for all three projections.

on the film. The tube is centered over the medial aspect of the right hip, and the first exposure is made (1 mm. focal spot and 90 kv are preferred but are not essential). The tube is then shifted transversely across the table (thereby also across the long axis of the patient) by 10 cm., and a second exposure is made on the same film, while the patient and the cassette remain in their original position. A radiograph of the pelvis, consisting of two contiguous rectangles, is thus obtained. From the geometrical theorem that parallel lines between parallel lines remain equal in length regardless of their obliquity (Fig. 1), it is obvious that any transverse pelvic diameter measuring 10 cm. will be depicted on the film in actual size, with extreme accuracy. Careful centering is not necessary, and intentional as well as unintentional angulation of the x-ray tube is permissible. The procedure thus differs from orthodiagraphy and scanography, both of which require perpendicular projection. Overlapping of the two rectangles on the film, or their separation by an unexposed zone, is of no consequence, since it is only the projection of the *end points* of the dimension to be measured which is of importance here.

In earlier experiments, the unexposed half of the film was covered by a lead plate during the first exposure. This plate was then shifted over the exposed part prior to the second exposure. It was soon discovered that this was entirely unnecessary, since the rectangular cone protected the unexposed portion of the film completely. Therefore, neither the patient nor the cassette is now manipulated between the two exposures.

PHYSICAL ACCURACY OF THE METHOD

The only major factor controlling the presence or absence of radiographic distortion in orthometric radiography is the *difference* between the length of the tube shift and the actual length of the dimension to be measured. If the tube shift is smaller than the dimension to be measured, a slight magnification results; if the tube shift is larger than this dimension, there is a slight minification. The approximate error (in round figures) for a target-film distance of 40 inches (1 meter), a tube shift of 10 cm., and table-top technic is shown in Table I. This error can be further reduced, or eliminated altogether, by the taking of a second orthometric view, for which the tube shift is made equal in length to that of the pelvic diameter under scrutiny. This can be accomplished by either of two methods:

(*a*) *Anticipation:* Two or three ortho-

TABLE I: POSSIBLE ERRORS IN MEASUREMENT OF TRANSVERSE DIAMETERS IN ORTHOMETRIC PELVIMETRY

Actual Pelvic Dimension (cm.)	Error for: Transverse Diameter of Inlet (mm.)	Bispinous Diameter (mm.)		Bituberous Diameter (mm.)
8.0	−2.5	−1.2		−2.0
8.5	−1.9	−0.9		−1.5
9.0	−1.2	−0.6	Diagnostically important range	−1.0
9.5	−0.6	−0.3		−0.5
10.0	No error	No error		No error
10.5	+0.6	+0.3		+0.5
11.0	+1.2	+0.6		+1.0
11.5	+1.9	+0.9		+1.5
12.0	+2.5	+1.2		+2.0

metric views with a variety of tube shifts are taken in a routine manner. One of these will inevitably show an error of less than 0.5 mm. If the bispinous diameter is the only one of interest, a 9 cm. and 10 cm. tube shift are recommended.

(*b*) *Guided Adjustment:* The length of the pelvic diameter is measured on the first orthometric view. The tube shift is adjusted thereafter so as to equal this measurement and a second orthometric view is taken accordingly. The theoretical geometrical error will then lie below 0.2 mm.

TECHNICAL RESULTS

Test films on dry pelves (elevated by spacers above the film so as to simulate obese patients) have shown this method to be extremely accurate. All films were measured with a precision consistently within 0.6 mm.[3] On pregnant patients no verification of measurements could be obtained,[4] but there is no reason to believe that the error here is greater, provided the patient did not move between the two exposures. In order to eliminate patient movement as a possible source of error a simultaneous exposure with two x-ray tubes can be employed, but only tubes with a narrow housing, *e.g.*, Dynamax 20, can be mounted sufficiently close to each other to provide an interfocal distance of 10 cm. It is not necessary that the target-film distance of both tubes be the same. In order to approximate the two central beams further, one tube may be mounted above the other.

Orthometric views can more conveniently be obtained with the conventional 8 : 1 Bucky grid, but the geometrical error is then slightly larger because of the increased object-film distance.[5] When the new 12 : 1 cross-hatched stationary Lysholm-Schoenander wafer grid is used instead of the 7 : 1 grid cassette, the orthometric view taken with table-top technic is of superior radiographic quality, excelling conventional radiographs of the pelvis by far. In a number of cases the orthometric view was the only one permitting identification of the ischial spines, while conventional inlet views and even supine views of the pelvis of the same patient taken through a 16 : 1 Bucky grid failed. On the orthometric view the measurements are read directly and require no correction if they lie within the limits outlined above. If they exceed these limits, accurate mensuration is no longer clinically required. If, however, correction is desired, 1.0 mm. can be added to or subtracted from the result for every centimeter of shift discrepancy.

MATHEMATICAL CONSIDERATIONS

The mathematical basis of the orthometric projection is as follows:

$$d = \frac{\left(\frac{\text{target-film distance}}{\text{object-film distance}} - 1\right) \cdot m + s}{\frac{\text{target-film distance}}{\text{object-film distance}}} \qquad (1)$$

when d is the actual length of the pelvic diameter under scrutiny, m the length of the diameter as measured on the ortho-

[3] The fact that there is a discrepancy at all, minimal though it is, is explained by shrinkage or swelling of the radiographic film after the exposure is made. This might be avoided by the use of photographic material designed for aerial mapping.

[4] Control measurements of the same patient by the method of Ball or Colcher and Sussman are discussed in the clinical part of this paper.

[5] At present this is the routine at Presbyterian Hospital, and a test is being performed on the clinical usefulness of this modification. To improve contrast, a Camp cassette is now being used in the Bucky tray. All cases reported here were measured with the table-top technic, as described earlier in this report.

metric film, and s the length of the tube shift. For a target-film distance of 100 cm. (or approximately 40 inches), which is the one most commonly used to date, this formula reduces to:

$$d = \frac{19m + s}{20}$$

for an object-film distance of 5 cm. (1*a*)

$$d = \frac{9m + s}{10}$$

for an object-film distance of 10 cm. (1*b*)

$$d = \frac{6m + s}{7}$$ for an object-film distance of approximately 14 cm. (1*c*)

When the tube shift is equal to the diameter to be projected, no distortion occurs and $d = m$. This favorable condition is independent of the target-film distance used. . An orthometric view can also be obtained, therefore, with antiquated x-ray machines employing shorter target-film distances. A discrepancy between tube shift and length of pelvic dimension, however, will cause a 50 per cent greater error with a short 30-inch target-film distance; conversely, a long 2-meter target-film distance will reduce the geometrical error to one-half of that encountered at a target-film distance of 40 inches.

Rotation of the patient causes foreshortening of the orthometric projection of a pelvic diameter according to Formula 2:

$$d = \frac{m}{\cos \theta} \qquad (2)$$

when d again is the actual length of the diameter under scrutiny, m its measurement on the orthometric radiograph, and θ the angle of rotation. Therefore, rotation of the patient by 5 1/2° causes 0.5 per cent foreshortening; rotation by 8°, 1.0 per cent foreshortening; by 10°, 1.5 per cent foreshortening. Rotation of the patient also adversely affects all conventional methods of pelvimetry, where its undesirable effects may be even greater. In general, rotation in excess of 3° can be avoided. This keeps this error on the orthometric view below 0.2 per cent.

CLINICAL APPLICATION OF THE ORTHOMETRIC VIEW

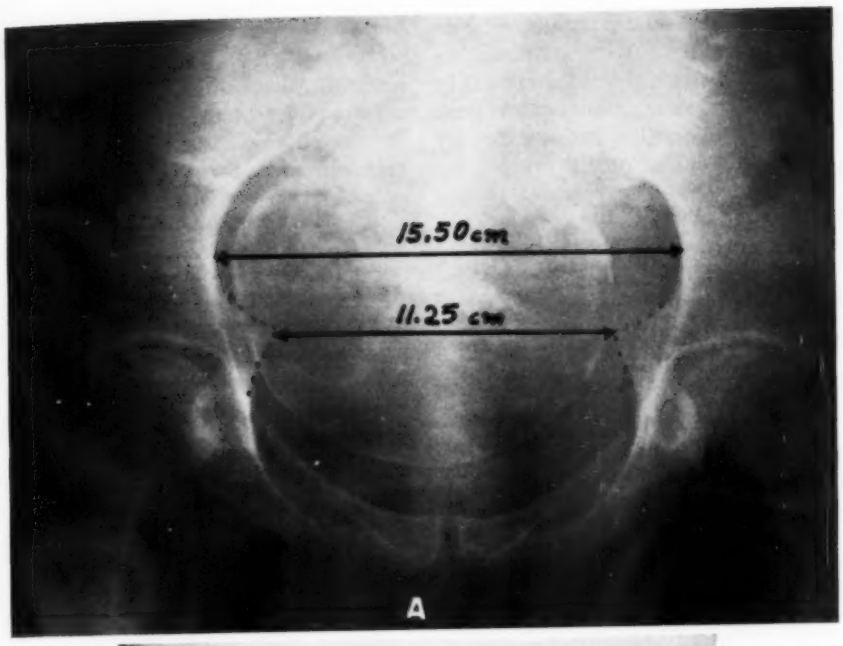
It remained necessary to investigate the clinical usefulness of the orthometric method by determining whether it can increase the number of correct obstetrical prognoses made by roentgen cephalopelvimetry, or whether an increased physical accuracy of measurements is superfluous.

Other studies have shown the accuracy of conventional roentgen cephalopelvimetry in the prediction of the outcome of labor to be good only when radiographs have shown absence of disproportion. When disproportion is revealed, the clinical accuracy is only fair; it has been reported to lie between 77 and 85 per cent in assessable cases (1, 2). In the author's study (3) of 350 cases, the Ball method was found to be 96 to 99 per cent accurate in normal patients, but only 80 per cent in cases in which disproportion was shown roentgenographically, and only 73 per cent if the mid-pelvis alone is analyzed.

In this series of cases, the roentgenograms were obtained prior to delivery, but the measurements were made by the radiologist after delivery. An analysis of the errors disclosed that the deficiency of the method lay chiefly in measurement of the bispinous diameter of the mid-pelvis. This suggested that an orthometric view of transverse pelvic diameters alone might lead to improvement of the clinical results of cephalopelvimetry, though it was realized that theoretically a greater benefit might be derived from application of the orthometric method to *all* pelvic dimensions and fetal skull diameters commonly used in clinical cephalopelvimetry. A comparison was therefore made of the results obtained by the orthometric method with those obtained by the conventional method in the same patients.

METHOD OF INVESTIGATION

Cephalopelvic roentgen measurements obtained on pregnant women at or near term were computed according to the method of Ball (4) by comparing the volume of the fetal head with the volume



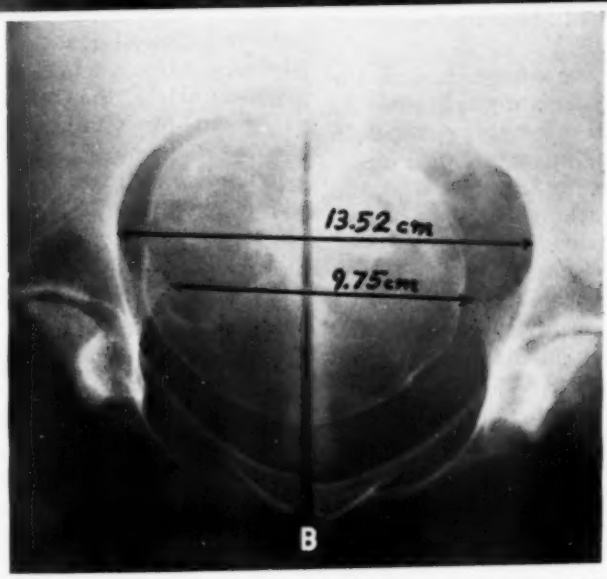


Fig. 2. A. Conventional supine view of the pelvis of a pregnant woman. The transverse diameters of the pelvis are enlarged by the divergent x-ray projection.

B. Orthometric view of the same pelvis obtained with a tube shift of 10 cm. and reproduced at the same scale as A. The bispinous diameter appears on this radiographic film without any significant enlargement because the tube shift and the length of the diameter are practically the same. The transverse diameter of the inlet is slightly enlarged here (by 3.5 mm.), but since it is larger than 12 cm., its exact mensuration is not of clinical importance.

All figures indicate length of diameter as measured on the radiograph.

capacity of certain pelvic diameters. The roentgen measurements were obtained simultaneously by two different methods in 20 patients. Particular attention was paid to measurement of the bispinous diameter of the mid-pelvis. The results were compared and the clinical correlation to the obstetrical outcome recorded.

Method I consisted of placing a perforated centimeter metal ruler at the approximate level of the transverse pelvic diameter and radiographing it together with the pelvis of the supine patient as originally described by Colcher and Sussman (5). This method for correcting transverse pelvic diameters will be referred to as a "conventional method."

Method II consisted of obtaining an orthometric view of the pelvis in the manner described earlier (pp. 753–754). This view was used only for precision measurements of the transverse diameter of the pelvic inlet and of the bispinous diameter of the mid-pelvis.

The sagittal pelvic diameters and the fetal skull measurements were obtained by the method of Ball. For this purpose an upright lateral view was taken with a perforated metal ruler in the patient's anal fold. This might also be called a conventional method. The corrected measurements were then combined with those of Method I and Method II, and the degree of cephalopelvic disproportion was expressed in c.c. of volume difference according to the original concept of Ball.

The comparison of these two methods was confined exclusively to measurements of the transverse diameter of the pelvic inlet and of the bispinous diameter of the mid-pelvis, for at present application of the orthometric view is limited to transverse diameters. Each patient was then classified according to the degree of roentgenometric cephalopelvic disproportion into one of three groups: (A) no disproportion; (B) borderline disproportion; (C) high disproportion (3).

The transverse diameter of the pelvic inlet did not affect this classification in any of the cases listed here, since it happened to be large in all instances observed. The comparison centered, therefore, principally on the effect of the bispinous diameter on the roentgen classification and its correlation with the actual obstetrical outcome.[6]

PATIENT MATERIAL

All patients studied were clinical borderline cases in which the referring obstetrician felt unable to determine the presence or absence of cephalopelvic disproportion without the help of roentgen examination. This explains why there were only 2 cases of suspected inlet disproportion in the group (Cases 13 and 19, Table II).

Inlet disproportion is more often diagnosed without the help of roentgenograms in this institution. When roentgenometry is requested in such instances it is to confirm a clinical conviction rather than to resolve a clinical doubt. This is not so in the case of suspected mid-pelvic disproportion. Here the radiologist's opinion is sought for solution of an important clinical problem. In diagnosis of mid-pelvic disproportion lies the potentially greatest contribution of roentgenometry to the management of labor.

FINDINGS

The findings of this comparative study are summarized in Table II. In 5 cases, the orthometric view led to improved classification and thereby to more accurate prognosis. In 2 of these, the classification changed from borderline to definite (Case 2 from B to C and Case 9 from B to A). In each the new classification proved correct. In the remaining 3, the orthometric view was responsible for a change of the classification from C to B. Its value here lay in prevention of an

[6] Since this writing a case has been encountered (not included in this series) in which the orthometric view was the only one of three different methods which yielded correct measurements of the transverse diameter of the inlet of an anthropoid pelvis and led correctly to the diagnosis of inlet disproportion.

TABLE II. COMPARATIVE STUDY OF CONVENTIONAL CEPHALOPELVIMETRY AND THE ORTHOMETRIC METHOD

Case	Corrected Measurements of Transverse Pelvic Diameters Obtained by Conventional Method		Roentgen Classification*	Direct Measurements of Same Diameters Obtained by the Orthometric Method		Roentgen Classification*	Clinical Outcome
	Inlet (cm_t)	Mid-pelvis (cm.)		Inlet (cm.)	Mid-pelvis (cm.)		
1	13.0	10.5	A	13.0	10.0	A	Normal delivery
2	12.6	8.6	B	12.6	*8.4*	*C*	Cesarean section for cephalopelvic disproportion
3	12.8	9.6	B	12.6	9.6	B	Normal delivery with low forceps
4	13.5	11.0	A	13.5	11.1	A	Normal delivery
5	12.8	10.4	B	12.4	10.1	B	Normal delivery
6	11.5	9.2	B	11.5	9.4	B	Cesarean section for cephalopelvic disproportion
7	13.4	10.9	A	13.4	11.0	A	Normal delivery
8	13.4	10.4	A	15.1	10.9	A	Cesarean section *not* for cephalopelvic disproportion
9	12.8	10.4	B	12.9	*11.0*	*A*	Normal delivery
10	12.6	10.5	B	12.4	10.8	B	Vaginal delivery with 36-hour labor
11	12.9	9.7	C	12.9	*10.3*	*B*	Normal delivery with low forceps
12	12.5	11.1	A	12.5	11.0	A	Normal delivery
13	13.8	11.2	C†	13.2	10.7	C†	Cesarean section for cephalopelvic disproportion
14	12.4	9.3	C	12.3	*9.7*	*B*	Normal delivery with low forceps
15	12.2	9.7	C	11.8	*9.9*	*B*	Normal delivery with low forceps
16	12.8	9.3	B	12.9	9.5	*B*	Cesarean section for fetal distress
17	14.4	11.6	A	12.6	10.8	A	Normal delivery with low forceps
18	11.0	7.4	C	11.4	7.6	C	Cesarean section for cephalopelvic disproportion
19	13.7	11.7	C†	13.6	11.15	C†	Normal delivery, precipitous
20	12.1	9.5	C	11.9	9.7	C	Cesarean section for prolonged labor of 40 hours (cephalopelvic disproportion, inertia, or both?)

* Prognostic roentgenometric classification of cephalopelvic disproportion resulting from measurement shown by figure just preceding the classification: A. No cephalopelvic disproportion roentgenographically. B. Borderline disproportion roentgenographically. C. High disproportion roentgenographically. For further explanations, see (3) in bibliography. Orthometric measurements resulting in a change of classification are *italicized*.

† Classified as "C" because of a short anteroposterior diameter of the inlet. Roentgen prognosis was not based on transverse diameters here.

error. In all 3 cases delivery was *per vaginam*, though the conventional method had erroneously labeled them as showing high disproportion. According to the orthometric view, a borderline disproportion only was present.

The roentgen diagnosis of cephalopelvic disproportion, based upon the conventional method of measurement, was in no instance superior to that based on the orthometric view, despite the fact that the management of labor was based upon the conventional method alone, the orthometric view having been disregarded completely by the obstetrician in this initial series.

SUMMARY

While the clinical accuracy of roentgen cephalopelvimetry is high when radiographs reveal *absence* of disproportion, this is not the case when roentgen measurements suggest the *presence* of disproportion. The most frequent cause of error in a series of 350 pelvimetries analyzed was inaccurate measurement of the bispinous diameter of the pelvis.

A method is described which permits precision measurements of the bispinous and all other transverse pelvic diameters without the help of corrective computations or auxiliary devices. This has been

termed "orthometric pelvimetry." The "orthometric view" consists of two half-images of the pelvis which appear on the same radiograph. It depicts transverse pelvic diameters in actual size and the results are accurate within 0.5 mm. The orthometric method can be applied to any system of cephalopelvimetry which requires the measuring of transverse pelvic diameters.

In the roentgen diagnosis of cephalopelvic disproportion, the orthometric view proved to be clinically more accurate than the conventional pelvimetry radiograph, producing a better correlation between measurements and obstetrical outcome. In 2 out of 20 cases the orthometric view led correctly from a doubtful to a definite x-ray diagnosis, while in 3 others it prevented gross radiological errors.

Though the total number of cases studied for the simultaneous comparison of the two different methods is still small, it is steadily increasing. At this stage of the investigation, one can safely conclude that the orthometric view is capable of raising the clinical accuracy of cephalopelvimetry significantly. It may make it possible to diagnose high disproportion in clinically doubtful cases with an accuracy of more than 90 per cent.

The orthometric view is based on an old geometric principle. Its application to pelvimetry has been made possible by the following observations:

(1) Precision pelvimetry is needed only within a narrow range of pelvic measurements.

(2) Orthometric pelvimetry is completely independent of the obliquity of x-rays producing the image. Accurate centering of the tube is unnecessary, since no perpendicular projection is required.

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SUMARIO

Radiografía Ortométrica para la Roentgenometría Obstétrica

Aunque la exactitud clínica de la céfalopelvimetría roentgenológica es alta cuando las radiografías revelan *falta* de desproporción, no sucede así cuando las mediciones roentgenológicas sugieren la *presencia* de desproporción. En una serie de 350 pelvimetrías, la causa más frecuente de error fué la medición inexacta del diámetro biespinoso de la pelvis.

Descríbese aquí un método que permite hacer mediciones precisas de los diámetros biespinoso y todos los demás transversos de la pelvis sin la ayuda de cómputos rectificadores o artefactos auxiliares. Este método ha sido denominado pelvimetría ortométrica. La "vista ortométrica" consta de dos semi-imágenes de la pelvis, que aparecen en la misma radiografía, y reproduce los diámetros transversos de la pelvis en su tamaño real con una variación que no excede de 0.5 mm. en los resultados. Puede aplicarse a todo sistema de céfalopelvimetría que requiera la medición de los diámetros transversos de la pelvis.

En el diagnóstico roentgenológico de la desproporción céfalopelviana, la vista ortométrica resultó ser clínicamente más exacta

que la habitual radiografía pelvimétrica, mostrando mejor correlación entre las mediciones y el resultado obstétrico. En 2 de 20 casos la imagen ortométrica condujo certeramente de un diagnóstico roentgenológico dudoso a uno bien definido, mientras que en otros 3 impidió cometer graves errores radiológicos.

En esta etapa de la investigación, cabe deducir sin temor que la vista ortométrica es capaz de realzar la exactitud clínica de la céfalopelvimetría en forma importante.

EDITORIAL

New Radiographic Contrast Agents and Antiquated Scientific Reporting

Editors of journals devoted to radiology are continuously battered by reports, mostly favorable, on new contrast agents for urography, cholecystography, myelography, bronchography, etc. Encouraged by the manufacturers, many investigators report clinical comparisons of the new with the old. The flood of such reports makes it almost inevitable that publication will frequently be so delayed that, by the time of its appearance, the information will have become "old stuff" in the rapidly moving field of pharmaceutical product development. Actually it is neither possible nor desirable to publish the experience of every worker in this field. One good study often yields more useful information than several poorly planned series embracing many times the number of cases. Valuable journal space is conserved through preferential publication of the former. It follows that to editors of scientific periodicals, statistical significance should be, and is, important in weighing the merits of articles under consideration.

The personal honesty of a scientist cannot serve as substitute for basic knowledge and use of the scientific method. The danger of an inaccurate conclusion is not measured in terms of good intentions, although these may excuse it. Fortunately, good methods are usually dictated by what is loosely defined as "common sense." That a need for this factor exists is well exemplified by numerous, often misleading reports submitted for publication. In making and reporting clinical comparison studies, many common pitfalls can be avoided through adherence to simple general principles such as the following.

Planning should always precede the collection of data. Ideally, equal series of new and old agents should be run simultaneously (*e.g.*, alternate cases) in such a manner that the identities of the patients are unknown to the physicians giving the drugs and evaluating the results (reactions and radiographs). This so-called "blindfold" alternate case method is of great value in preventing the investigating physicians from influencing the data. The statistical pitfall of bias through case selection is further reduced by the simple expedient of including all patients referred for examination. For example, in a study of contrast agents for intravenous urography, no case should be discarded from the series because of private-patient status or excluded from the analysis of data because of poor renal function, patient preparation, or radiographic technic. Poor preparation is not due to differences between contrast agents and it is therefore unlikely to influence a statistically significant comparison. The type of patient available for a clinical study represents unavoidable selection. The case material should therefore be taken into consideration when interpreting data and should also be described in the report. Similarly, the study should be continuous, and the evaluation of films so planned as to minimize bias. In the collection of data, randomization is easily achieved by the "alternate case" method. If this method is used, the order of film evaluation might preferably be left to chance (like the order of cards in a well shuffled deck), thus tending to prevent the emergence, recognition, and consequent bias produced by possible differences.

Within the conditions of the study, data

(*per se*) cannot mislead. The interpretation can. Thus, conclusions should always be subjected to *sufficient* statistical appraisal to establish their validity, or lack of validity. In most instances, this is a simple task. Facts in the scientific sense (data) must never be confused with opinions about facts.

Scientific publications occasionally provide incriminating evidence of *unconscious* dishonesty on the part of members of the medical profession in the preparation of reports. This is in part due to failure to follow basic principles governing the acquisition of all knowledge, particularly scientific. The biostatistician justly deplores the frequency of unwarranted conclusions which appear in the public utterances of his unmathematical medical colleagues. Incidentally, the situation is partly of his own making. His writings, intended to simplify statistics for the layman (*i.e.*, the physician), are pertinent. In the hypothetical book, "Biostatistics Made Easy," the first ten pages are devoted to the contention that fifth-grade arithmetic is sufficient unto the reader's need. Why, then, are the last ten chapters composed of page-long formulae, log tables, and other various cryptographic symbols? The brevity of life and the demands of present-day economy do not favor simultaneous achievement in medicine and statistical methodology. Fortunately, however, the basic principles of biostatistics require common sense, not calculus. The biostatistician aids the clinician in at least two major services: First, he teaches how to plan a study so as to obtain the desired information most efficiently. The "blindfold" alternate case technic for clinical comparisons frequently can produce the desired information with a small series; conversely, failure to consider in advance factors such as selection could invalidate the effort expended in the accumulation of many times the number of observations. Second, the biostatistician provides methods for appraising the reliability of conclusions. Such appraisals, sometimes but not always mathematical in nature, reveal the advantages of the planned experiment (a luxury sometimes denied by the limitations of clinical medicine).

Mention should be made of the unreliability of "adding up" the results of different investigators. Certain medical advertisements to the contrary, this practice reduces rather than strengthens the value of each contribution. Enthusiasm for a product does not justify the inclusion of misleading information in medical advertisements, since the health of the community is at stake. Self-vigilance, fortunately practised by most reputable pharmaceutical concerns, offers a practical solution to this important problem. If the medical profession is to demand high standards for the advertisements appearing in our scientific periodicals, it should be willing to set a good example in the center pages of the same journals.

CHARLES T. DOTTER, M.D.
University of Oregon Medical School

ANNOUNCEMENTS AND BOOK REVIEWS

EIGHTH INTERNATIONAL CONGRESS AN INVITATION

The Section on Radiology of the Los Angeles County Medical Association would like to offer hospitality and entertainment to all foreign radiologists and their families who intend to pass through Los Angeles on their way home after attending the Eighth International Congress of Radiology. No scientific conferences or meetings are planned. Sight-seeing tours in small groups, visits to movie studios, entertainment in the homes of local radiologists, and visits with them in their offices and departments, constitute the planned features.

A cordial invitation is extended to all radiologists and their families from outside of the United States, who are participating in the Congress to be guests of the Los Angeles County radiologists on July 30 and 31, in Los Angeles, Calif.

For particulars write to Stefan P. Wilk, M.D., Secretary, University of California Medical Center, Los Angeles 24, Calif.

THE ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

The next meeting of the Rocky Mountain Radiological Society will be held at the Shirley-Savoy Hotel in Denver, Colo., Aug. 16–18, 1956. The present officers of the Society are: President, Maurice D. Frazer, M.D., Lincoln, Nebr.; President-Elect, John S. Bouslog, M.D., Denver, Colo.; 1st Vice-President, C. S. Hatchett, Jr., M.D., Amarillo, Texas; 2nd Vice-President, Ralph C. Moore, M.D., Omaha, Nebr.; Secretary-Treasurer, John H. Freed, M.D., 4200 E. 9th Ave., Denver 20, Colo.; Historian, H. Milton Berg, M.D., Bismarck, N. Dak.; Executive Committee, Gerald S. Maresh, M.D., Denver, Colo., Angus K. Wilson, M.D., Salt Lake City, Utah, Peter E. Russo, M.D., Oklahoma City, Okla.; Counselor, American College of Radiology, Robert D. Moreton, M.D., Fort Worth, Texas; Alternate Counselor, Vernon Bolton, M.D., Colorado Springs, Colo.

OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

Four courses are being offered in 1956 by the Oak Ridge Institute of Nuclear Studies: Uses of Radioisotopes in Hematology, May 14–19, General Medical Uses of Radioisotopes, May 21–25, Supervoltage and Gamma-Beam Therapy, July 15–18, and External Radioisotope Measurement Technics, Sept. 24–29.

The course on Supervoltage and Gamma-Beam Therapy, to be given in July, is scheduled as a seminar and will be open to physicians interested in problems of teletherapy. Topics to be considered include calculations of dosage from both fixed and moving-field machines, problems of design and installation of the various types of commercial machines, and indications and contraindications for the use of teletherapy. Applications must be received by June 1.

The purpose of the course on External Radioisotope Measurement Technics is to familiarize participating physicians with the various clinical methods of external measurement of radioactivity, including liquid-counting, spectrometry, scanning, and multiple-counter technics. The deadline for receipt of applications for this course is Aug. 1.

Further information and application blanks may be obtained from Dr. Ralph Overman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

NINTH ANNUAL CONFERENCE ON ELECTRICAL TECHNICS IN MEDICINE AND BIOLOGY

The Ninth Annual Conference on Electrical Technics in Medicine and Biology will be held at the Governor Clinton Hotel in New York City, Nov. 7–9, 1956. The Conference is sponsored by the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Instrument Society of America. In addition to the technical sessions, there will be field trips to installations of interest to those attending.

Titles and brief abstracts for proffered papers may be submitted to the Conference chairman, E. Dale Trout, General Electric Company, X-Ray Department, Milwaukee 1, Wisc.

ERRATUM

On page 410 of the article by Wilsey, Strangways, and Corney, "Experiments in the Photographic Monitoring of Stray X-Rays, Part I," in the March 1956 issue of RADIOLOGY, the word "quantities" in the second line from the bottom of the left-hand column is mistakenly used for "qualities." The phrase should read "qualities of x-rays and gamma rays."

Letter to the Editor

To the Editor of Radiology

DEAR DR. DOUB:

In RADIOLOGY **66**: 133, January 1956, Dr. Z. F. Endress presented a very adequate abstract of an article by Dr. G. Jacobson and me entitled "A Critical Evaluation of the Roentgen Criteria of Right Ventricular Enlargement" (Circulation **11**: 391, 1955). He added a comment as follows:

"The point should have been made also that all the cases were of congenital origin, whereas the [generally accepted] criteria were established chiefly by the study of acquired heart disease in which the heart develops normally for some period of time before the cause of the enlargement appears."

The implication is that we had not considered this aspect and that our conclusions do not apply to acquired disease. I feel that this is important and should be clarified. We chose to study congenital lesions in order to evaluate right heart enlargement uncomplicated by other cardiac changes. We pointed out, however, that we had previously studied cor pulmonale and came to the same conclusions when there was no complicating disease. We also referred to our previous work with mitral valvular disease in which it was shown by angiocardiography that the signs commonly ascribed to right ventricular enlargement were, in fact, due to left auricular dilatation and its consequences. Since these previous publications, our experience, which has not been small, has confirmed these impressions. Our views are shared, I believe, by most authors who have a considerable experience with angiocardiography.

I thought this subject of sufficient importance perhaps to merit comment in your columns. I should like to emphasize that, in our opinion, it is as difficult to evaluate accurately and objectively the size of the right ventricle in acquired heart disease as it is in the congenital lesions. By objective, we mean the evaluation of the cardiac contours with no knowledge of the patient clinically.

It is our belief that the established criteria are not valid but that right ventricular enlargement can frequently be inferred when the left auricle or pulmonary artery is dilated.

Sincerely yours,
MARCY L. SUSSMAN, M.D.
Phoenix, Ariz.

Books Received

Books received are acknowledged under this heading and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

PEDIATRIC X-RAY DIAGNOSIS. A TEXTBOOK FOR STUDENTS AND PRACTITIONERS OF PEDIATRICS, SURGERY & RADIOLOGY. By JOHN CAFFEY, A.B., M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; Attending Pediatrician and Roentgenologist, Babies Hospital and Vanderbilt Clinic, New York City; Consulting Pediatrician, Grasslands Hospital, Westchester County, N. Y., and New Rochelle Hospital, New Rochelle, N. Y.; Consulting Roentgenologist, Orange Memorial Hospital, Orange, N. J.; Consultant in Pediatric Roentgenology, The New York Hospital, New York City. A volume of 1060 pages, with 1267 illustrations. Published by the Year Book Publishers, Inc., 200 East Illinois St., Chicago, Ill. Third Ed., 1956. Price $28.00.

HÄMODYNAMIK DES HERZENS IM RÖNTGENBILD MIT BESONDERER BERÜCKSICHTIGUNG DER HERZKATHETERISIERUNG UND DER ANGIOKARDIOGRAPHIE. Fortschr. a. d. Geb. d. Röntgenstrahlen. Ergänzungsband 76. By Dr. P. THURN, Priv.-Doz. an der Universität Bonn. Foreword by Prof. Dr. Paul Martini, Bonn. A volume of 168 pages, with 81 illustrations. Published by Georg Thieme Verlag, Stuttgart, 1956. Distributed in the United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 48.–

Book Reviews

ANATOMIE RADIOGRAPHIQUE DU MASSIF FACIAL. SCHEMAS RADIOGRAPHIQUES DES PRINCIPALES INCIDENCES. By MAURICE BOUCHET, Oto-Rhino-Laryngologiste des Hôpitaux de Paris, and GEORGES DULAC, Electro-Radiologiste, Ancien Chef de Service de la Fondation Curie, with the collaboration of RENÉ PAILLER, Membre correspondant de la Societé de Laryngologie des Hôpitaux de Paris. A volume of 188 pages, with 103 illustrations. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris, 1955. Price, 2,800 fr. (paper bound) or 3,600 fr. (cloth).

The purpose of this book is the exclusive study of the facial mass—that is, the orbits, the nasal fossae, and their accessory cavities—the nasopharynx, and the mandible. For the radiographic study of these structures the following views are suggested: fronto-nasal, nasomental, lateral, oblique (Rhese), basal (Hirtz), and tomographic sections.

Labeled sketches of the various planes superimposed in each of the above views are included, followed by composite drawings of each. Roentgenograms taken in the various positions are reproduced, with accompanying drawings to demonstrate pertinent anatomic landmarks.

The Appendix gives added information concerning positioning and technic. An extensive bibliography is presented.

RADIODIAGNOSTIC EN OPHTHALMOLOGIE. By EDWARD HARTMANN AND EVELYN GILLES. A volume of 412 pages, with 497 illustrations. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris. Price 5,000 fr. (cloth bound, 5,700 fr.).

This monograph is a sequel to, rather than a second edition of, Dr. Hartmann's clinical atlas on *Radiology in Ophthalmology* originally published in 1936.

It affords a more complete treatise on the subject, correlating technical, anatomic, and clinical data illustrating the value of diagnostic radiology in ophthalmology.

Benign and malignant tumors, aneurysms, varicoceles, dermoid and hydatid cysts, fractures, and other lesions involving the structures in and around the orbits are described and illustrated. Tomography has proved to be most useful in the study of these conditions. Cysts or tumors which do not erode bone may be outlined with injection of air into the retrobulbar space or into the capsule of Tenon. A table of orbital tumors gives the age group in which these are to be found, and lists the appropriate examinations, radiologic and clinical signs, laboratory data, and course.

Individual chapters are devoted to calcification in the orbits, foreign body localization, the lacrimal passages, paranasal sinuses, teeth, petrous pyramids, and sella turcica. The cranial vault is also considered in detail. Cerebral air and vascular studies are presented, with a special discussion of orbital phlebography. Even lesions of the cervical spine may indirectly affect the eyes by involving the sympathetic nervous system.

This monograph enlarges upon the rather brief treatment accorded in most works to the roentgen diagnosis of conditions involving the eye and thus serves a useful purpose.

AUS- UND WEITERBILDUNG IN DER MEDIZINISCHEN STRAHLENKUNDE. Reden und Denkschriften. Published by the Deutsche Röntgengesellschaft. A booklet of 42 pages. Georg Thieme Verlag, Stuttgart, 1955. Distributed in the United States and Canada by the Inter-continental Medical Book Corporation, New York, 1955. Price DM 3.60—($0.85).

This booklet, issued by the German Roentgen Society, contains material regarding the organizational phase of undergraduate and postgraduate radiological training in Germany. The prefatory remarks are signed by A. Kohler and H. Lossen, President and Vice-President of the organization. Included are papers by O. Glasser (Cleveland) on the American Board of Radiology, and by E. Berven (Stockholm) on the study of radiology in Sweden, presented at the September 1954 meeting of the German Society in Wiesbaden. R. Glocker discusses the position of radiology in the universities and H. Holthusen its place in medical practice. G. V. Pannewitz offers a set of proposals for the creation of the title of specialist in radiology (*Facharzt für Röntgen- und Strahlenkunde*), to be granted after four years of formal training and a final examination.

These efforts, intended to maintain a high specialty standard in Germany, make one cognizant of the achievements of organized medicine in America.

In Memoriam

LYELL CARY KINNEY, M.D.

1884–1956

A distinguished career came to an abrupt and tragic end on Feb. 1, 1956, when Dr. Lyell C. Kinney was struck and killed by an automobile in Del Mar, Calif.

Dean of Radiology and an elder statesman of medicine in California, Dr. Kinney was loved and respected by all of his colleagues, and his death is a distinct loss to the medical profession of that state and of the nation as a whole.

Born in Johnstown, Wisc., Lyell Kinney came to Los Angeles in his boyhood. He was graduated in 1901 from the Los Angeles High School, received the degree of Bachelor of Science from the University of Chicago in 1905, and the degree of Doctor of Medicine from the University of Pennsylvania in 1908. After twenty-seven months of internship at the German Hospital in Philadelphia, he returned to Los Angeles with the medical group of Drs. Moore, Moore, and White, and was appointed radiologist to the California Lutheran Hospital. In the Fall of 1915, he became the first radiologist in San Diego, where he lived for the remainder of his life. He served as Instructor in Radiology in the School of Medicine of the University of Southern California, and, during the first World War, served as radiologist in the U. S. Navy, where he reached the rank of Commander.

Dr. Kinney's career was a distinguished one, with many contributions to human knowledge. He was President of the San Diego County Medical Society in 1910, and President of the California Medical Association in 1930. In 1931, he initiated the formation of the Cancer Commission of the California Medical Association, and served for several years as a member of the Commission. From 1944 to 1948, he was a director of the American Cancer Society and played an important part in the establishment of the California division of that Society. He was one of the founders of the American Board of Radiology, a life member of the American College of Physicians, a member of the Radiological Society of North America, a Fellow of the American College of Radiology, and Past President of the American Roentgen Ray Society.

Dr. Kinney is survived by his wife, Mila, and his four children: Mrs. Edith M. Lashley, Miss Margery Kinney, Dwight F. Kinney, and Lyell Cary Kinney, Jr. May he rest in peace.

LOWELL S. GOIN, M.D.

Lyell C. Kinney, M.D.
1884–1956

Walter H. Ude, M.D.
1896–1956

WALTER HERMAN UDE, M.D.

1896–1956

The profession of medicine, and particularly radiology, suffered a severe loss with the sudden passing on Feb. 9, 1956, of Dr. Walter Herman Ude, who succumbed to coronary thrombosis while vacationing in Honolulu with his wife, who survives him.

Dr. Ude was born March 19, 1896, in Minnesota, and except for a period prior to his entrance into medical school when he served with the Armed Forces in France in World War I, spent his entire life in that state. Following his graduation from the University of Minnesota, where he was elected to Alpha Omega Alpha, Dr. Ude practiced medicine in Minneapolis for some thirty years. He entered the specialty of radiology as a student in 1926 and soon became an accomplished radiologist, completing his career as the senior member of the firm of Ude, Borman, Ahern, and Stone. In addition to his private practice, he acted at various times as roentgenologist to St. Andrews Hospital, the Eitel Hospital, and St. Mary's Hospital in Minneapolis.

For many years he was chief, and in his last years consultant of the Department of Roentgenology of the Minneapolis General Hospital. He was a devoted teacher and had attained the rank of Clinical Professor of Radiology at the University of Minnesota. It is notable that his last act before leaving for Honolulu was to lecture to the senior class at the University on obstetrical and gynecological radiology, a field to which he had contributed so much.

A member of many medical associations, including local and national radiological societies, he took an active part in organized medicine. For many years he was a Councilor, and during the past year a Vice-President, of the Radiological Society of North America. His activities in the Minnesota campaign to stamp out tuberculosis were of great importance and he is cited by Dr. Jay Myers, in a book on this subject as having made many personal sacrifices and rendered valuable service working with physicians to demonstrate how to produce satisfactory films of the chest. As president of the Minnesota Radiological Society in 1937 and 1938, and as a member of the Committee on Tuberculosis of the State Medical Association, Dr. Ude cooperated fully with the Minnesota Public Health Association in regard to problems in the diagnosis of tuberculosis.

Dr. Ude's major scientific contribution was his original description, in 1934, of a method for the roentgenologic diagnosis of placenta previa, an important development in obstetrical management. He also was the author of papers on such subjects as diaphragmatic hernia, osteitis condensans ilii, early lobar pneumonia, and others.

Walter Ude was a fine example of the physician who is a good citizen, taking an active part in the affairs of his community, while at the same time making an outstanding contribution to his own specialty. Above all, he was a man who loved and helped his family and friends to the full extent of his ability. His counsel and friendship will be greatly missed by all who knew him well.

LEO G. RIGLER, M.D.

WILLIAM H. DELSCAMP, M.D.

1870–1956

Dr. William H. Delscamp, senior radiologist of the Dayton, Ohio, area, died on Feb. 26 after a long illness. Dr. Delscamp was graduated from the Medical College of Ohio in 1900. He acquired his first x-ray machine in 1905 and had been a member of the Radiological Society of North America since 1919.

SYLVESTER FORD, M.D.

1906–1956

Dr. Sylvester Ford, a member of the Radiological Society of North America since 1936, died at his home in Detroit, Mich., March 11, 1956. Dr. Ford was born in Ann Arbor, Mich., and was graduated from the University of Michigan Medical School. He served as a Major during World War II. At the time of his death he was on the Staff of the Ardmore Hospital, Ferndale, Mich.

JOHN D. WONDER, M.D.

1880–1956

Dr. John D. Wonder, for nearly thirty years a member of the Radiological Society of North America died on March 2. Dr. Wonder was graduated from Pulte Medical College, Cincinnati, in 1905 and spent over half a century in the practice of medicine in the Dayton, Ohio, area.

WILLIAM J. CORCORAN, M.D.

1895–1955

Dr. William J. Corcoran, outstanding radiologist of Northeastern Pennsylvania, died on Dec. 31, 1955. He had been seriously ill for some eighteen months but on several occasions during that time had been able to return to limited practice for brief intervals.

Dr. Corcoran was born and raised in Old Forge, Penna., a small town just south of Scranton. He attended St. Thomas College (now the University of Scranton) and received his degree in medicine from Georgetown University, following which he served his internship at the Allentown General Hospital. Entering private practice in Old Forge, he became interested in radiology through his friendship with the late Byron H. Jackson, M.D., and attended Dr.

William J. Corcoran, M.D.
1895–1955

Jackson's clinics at the Moses Taylor Hospital, Scranton.

In 1924, Dr. Corcoran established an X-Ray Department in the Taylor Hospital, Taylor, Penna., a small hospital of forty beds. As time progressed, his interest in radiology increased. He was attending radiologist at St. Mary's, Mercy, Moses Taylor, St. Joseph's Maternity, and Scranton State Hospitals, Scranton; at St. Joseph's Hospital, Carbondale; Taylor Hospital, Taylor; and at West Mountain Sanatorium.

Doctor Corcoran was Past President of the Pennsylvania Radiological Society, a diplomate of the American Board of Radiology, a fellow of the American College of Radiology, a member of the Radiological Society of North America, of which he was a Vice-President in 1936, The American Roentgen Ray Society, The Philadelphia Roentgen Ray Society, and other scientific organizations. On the day of his death he completed his term as president of the Lackawanna County Medical Society. He was also a member of the Scranton Club, the Scranton Country Club, The Knights of Columbus, American Legion, and St. Paul's Roman Catholic Church.

Dr. Corcoran is survived by his wife, Mrs. Mabel Corcoran, two sons, and four daughters.

ROBERT L. HICKOK, M.D.
JOSEPH J. O'BRIEN, M.D.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Clinical Aspects of Cerebral Angiography in Children. Charles M. Poser and Juan M. Taveras. Pediatrics **16**: 73–80, July 1955.

A series of 131 cerebral angiograms were obtained on 90 children under the age of thirteen at the Neurological Institute of New York from 1944 through 1954. Diodrast was used in most cases, introduced percutaneously or by open vessel injection. In all but 2 instances the procedure was done under general anesthesia.

Angiography was of definite diagnostic value in 43.5 per cent of the patients. The radiologic findings are reserved for another communication.

No fatalities occurred and complications were mild and transient. They included hematoma of the neck (9 cases), convulsions (3 cases), respiratory difficulties (5 cases), hoarseness (1 case), pupillary inequality (4 cases), and petechiae over the face and neck (3 cases). The morbidity proved to be lower than that following pneumoencephalography in children.

Four tables.

JOHN F. BERRY, M.D.
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The Anterior Choroid Artery in Cerebral Angiography. Mario Lenzi. Radiol. clin. **24**: 202–210, July 1955. (In Italian)

The author discusses the significance of the anterior choroid artery in the angiographic diagnosis of deep-seated thalamic and ventricular tumors. This artery is seen in about 80 per cent of normal carotid angiograms. Its average caliber is 1 to 1.5 mm. It arises about 3 to 5 mm. above the origin of the posterior communicating artery, parallels the course of this latter vessel, and is directed toward the pineal gland. It is visualized for a distance of about 2 to 3 cm. Demonstration of any greater extent or any increase in caliber must be regarded as abnormal.

The author makes much of the fact that the posterior cerebral artery is on the same plane as the readily identifiable ophthalmic artery. The anterior choroid artery arises just above this plane.

Since the appearance of the anterior carotid artery can be the sole indication of a thalamic tumor, and since it can be important in the diagnosis of ventricular tumors, careful observation of the vessel is imperative. In common with other vessels useful in angiographic diagnosis, it exhibits the following changes: (1) displacement (inversion or straightening of the initial bend upward); (2) increased caliber and length, especially important in deep infiltrating gliomas and intraventricular tumors; (3) abnormal circulation, especially an arteriovenous shunt. In the last case, the basal vein is visualized early in the arterial phase.

Ten roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
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Vertebral Angiography: Percutaneous Lateral Atlanto-Occipital Method. Henry A. Maslowski. Brit. J. Surg. **43**: 1–8, July 1955.

Following a pertinent anatomical study, the author described his method of percutaneous vertebral angiography, which depends on puncture of the vertebral artery at the atlanto-occipital level from a lateral approach.

Routine axial and lateral films of the skull are first taken to determine any individual anatomical variation, and particularly the depth of the lateral mass of the atlas and the site of the mastoid process. General anesthesia with endotracheal intubation is used. The patient is placed face up with the neck flexed. Once the needle is *in situ*, extension of the head on the neck for the submentovertical projection, should this view be desired, is easily achieved without disturbing the needle. The puncture needle is 8 cm. long, 17 gauge, with a 45° bevel point and a special adapter for transparent plastic tubing. The needle is inserted through the skin as close to the tip of the mastoid process as possible and is advanced at right angles to the sagittal plane. At a depth of 1 to 2 cm. one may contact the tip of the transverse process of the atlas, and the needle should be adjusted to pass closely above it. In an average adult, the lateral mass of the atlas is encountered at a depth of about 5 cm. from the skin. The needle can then be manipulated into the groove between the wall of the lateral mass and the upper surface of the posterior arch of the atlas. This is done by short withdrawals, posterior tiltings, and reinsertions of the needle, making contact with bone on each occasion. After the artery is punctured, the needle is so manipulated as to advance the point into the lumen. The bevel of the needle must point dorsally or cephalad so that the injection is directed distally. The author used 14 to 16 c.c. of 35 per cent Iodopyracet for each injection. Commonly four injections were employed for lateral and axial views.

This procedure was used in 104 cases, with failure to obtain angiograms in 11 of these. Almost without exception, the vertebral artery was punctured within the first minute or two after insertion of the needle through the skin, but not always squarely enough to proceed with the injection. In the last 40 cases, the time of secure entry was never longer than 30 minutes; in 70 per cent it was under 5 minutes, and in the remainder 10 to 15 minutes. The number of injections of the contrast medium varied from three to eight.

Failures and some of the poorer results were attributable to: (1) facing the bevel of the needle proximally, which may interfere with distal filling of this small artery; (2) using too much local anesthetic in a thin-necked and small individual, which disposes to dislodgement of the needle and makes it more difficult to locate the artery in the novocain-sodden tissues; (3) using a needle of too large a bore or with too long a bevel; (4) misinterpretation of anatomical conditions; (5) restricting injection to one side, whereas the vertebral artery on the other side may have been of larger caliber; (6) attempting puncture through tumor tissue which had displaced the vertebral artery.

There was one death in the author's series which could be attributed to the examination. Postmortem a solid thrombus was found in the left vertebral artery. The assumption is that there was a temporary stagnation of blood in the segment of the artery between the site of the puncture and the point of junction with the opposite vertebral artery. This was believed to be due to temporary diversion of blood flow through the puncture needle during rotatin of the patient's head

to test the position of the needle, the larger caliber of which virtually obstructed the arterial lumen.

The author compares his procedure with various other technics of vertebral angiography. He believes that, of all the percutaneous methods, it offers the best chance of securely engaging the vertebral artery and that it is most comfortable for the patient. It is particularly suitable in cases of saccular or cirsoid aneurysmal formations on the borders of the vertebral and carotid circulatory fields, where discovery of accessory feeding vessels from the other system is essential. A disadvantage of the method is that it is not suitable for children.

[This is an excellent and complete presentation of an apparently satisfactory technic of angiography for a very elusive vessel, the vertebral artery. Our neurosurgical colleagues should be directed to this article. J.P.F.]

Eight angiograms; 3 drawings.

JOHN P. FOTOPOULOS, M.D.
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Vertebral Angiography by Retrograde Injection of the Brachial Artery. Purdue L. Gould, William T. Peyton, and Lyle A. French. J. Neurosurg. **12**: 369–374, July 1955.

Vertebral angiography has become of sufficient value in the diagnosis of lesions of the posterior fossa to warrant exploring new methods of accomplishing the procedure. The technics in general use are designed primarily for adults and are difficult to perform in children. The authors present their experience in 16 cases in which an attempt was made to fill the intracranial vascular tree by retrograde brachial artery injection. This series included 9 adults and 7 children, ranging in age from seven months to sixty-five years. Successful filling of the posterior fossa circulation was obtained in 5 of the 9 adults and in all of the children. In the 4 cases classed as unsuccessful, there was some contrast medium in the vessels, but it was considered insufficient for diagnostic purposes.

This technic has proved quite successful in children. In addition to the vertebral filling, there has been excellent visualization of the ipsilateral internal carotid circulation, with a single exception. Contralateral compression of the carotid artery in the neck improves the ipsilateral filling of the carotid system as seen on the anteroposterior view and may lead to adequate visualization of the distribution of both internal arteries. The filling of the right internal carotid circulation has been sufficient with this technic to justify its use in younger children in whom percutaneous puncture might be difficult. However, carotid arterial filling cannot be expected when the left brachial artery is injected because the contrast medium would need to travel through the left subclavian artery and then in a retrograde direction in the aorta to reach the origin of the common carotid.

This method is not recommended for use in adults except when attempts at vertebral angiography by the usual procedures have failed. The adult arteries are proportionately larger and the greater quantity of blood dilutes the "bolus" of contrast medium.

Four case examples are given, as well as a description of the technic.

Eight roentgenograms. FRANK LESKO, M.D.
Indiana University

The Collateral Circulation Following Middle Cerebral Branch Occlusion. Keasley Welch, James Stephens, Warren Huber, and Charles Ingersoll. J. Neurosurg. **12**: 361–368, July 1955.

The authors report 2 cases of occlusion of the primary branch of the middle cerebral artery. In both instances the collateral circulation was shown, by angiography, to come from the anterior cerebral artery branches rather than the unoccluded part of the cerebral system. The criteria establishing these observations are failure of the middle vessels to fill beyond the point of obstruction and delayed retrograde filling of the cortical branches of either the anterior or posterior cerebral arteries.

Six roentgenograms. JOHN W. COURTNEY, M.D.
Indiana University

Hemiplegia Caused by Cerebrovascular Thrombosis. An Arteriographic Study. Kenneth E. Livingston, Alfonso Escobar, and Gregory D. Nichols. J. Neurosurg. **12**: 336–344, July 1955.

The authors report an arteriographic study of 30 patients with hemiplegic "stroke," all having histories and clinical findings typical of cerebrovascular thrombosis involving the cortical motor system. The purpose was first to identify the occluding lesion if possible and, secondly, to attempt to correlate the arteriographic evidence with the clinical syndrome. The series included patients from twenty-three to eighty-five years of age, one-third being over sixty. The studies were done at intervals ranging from twenty-four hours to twenty-five years following the onset of hemiplegia. In the entire group no evidence was found that arteriography had a deleterious effect. In fact, in approximately one-third of the cases significant improvement in the clinical and neurologic status of the patient appeared directly following the procedure.

Arteriography was performed percutaneously in all cases, with 35 per cent Diodrast and serial films, usually with stereoscopic views. Bilateral arteriograms were not obtained in the earlier cases, and in 12 only the involved side was investigated. In the remaining 18 cases bilateral studies were made, usually in a single procedure. The latter course aids significantly in evaluation of the lesion, and in the authors' experience has presented no additional hazards to the patient. Eighteen of the 30 patients studied showed well defined vascular obstruction. In 8 cases the thrombosis was "extracerebral": 7 of these lesions involved the internal carotid artery at or distal to the bifurcation of the common carotid in the neck, and 1 involved the distal portion of the carotid siphon intracranially. In half of these patients the hemiplegia was intermittent and progressive in onset, sometimes over a period of hours, but more often over days, weeks, or months. In the group of patients with "intracerebral" obstruction and in those with "normal" arteriograms, such a mode of onset was much less common. In 10 cases, the obstruction was distal to the siphon and these are tabulated under the heading "intracerebral" thrombosis. In the remaining 12 patients the arteriograms were interpreted as being "within normal limits," although 2 of them showed changes that were believed to have pathological significance in relation to the hemiplegia.

This series is too small to permit reliable evaluation of many factors that may relate to the severity and course of the clinical disability. The authors state,

however, that "one difference between the 'normal' and abnormal arteriogram groups is suggested by our data. Although the hemiplegia seems equally severe, the potential for recovery appears greater in patients with 'normal' arteriograms than in those in whom major vascular occlusion is demonstrable."

It is proposed that further clinical study of cerebrovascular thrombosis be carried out—first to enlarge our knowledge of the vascular changes associated with the "stroke" syndrome, and ultimately to apply available data in an effort to reduce resulting disabilities.

Seven roentgenograms; 3 tables.

WILLIAM M. LOEHR, M.D.
Indiana University

The Ocular Significance of Intracranial Calcium Deposits. Joseph E. Alfano and Harvey White. Arch. Ophth. **54:** 77–91, July 1955.

In some cases the roentgen demonstration of intracranial calcium deposits may be regarded as normal; in others it may have a very definite ocular significance.

Calcifications may be seen normally in the pineal gland and choroid plexus of the lateral ventricles and as osseous plaques in the falx cerebri. Calcifications in the pacchionian bodies and the hypophysis, although less common, may also occur normally.

The conditions of prime ophthalmologic importance in which intracranial calcifications may be seen include toxoplasmosis, Sturge-Weber syndrome, tuberous sclerosis, intracranial arterial aneurysms, craniopharyngioma, pituitary adenoma, slow-growing gliomas and meningiomas, hypoparathyroidism, subdural hematoma, cerebral arteriovenous malformations, and parasitic conditions. Intracranial calcifications may also be found in such conditions as encephalitis, lead intoxication, extreme old age, amaurotic idiocy, epilepsy, and old intracranial abscesses, tuberculomas, and hematomas.

Ten illustrative cases are reported.

Twenty-seven roentgenograms; 4 photomicrographs; 3 photographs; 1 drawing.

Calcification of the Cavernous Portion of the Internal Carotid Artery. Angelo Nerli. Radiol. med. (Milan) **41:** 676–686, July 1955. (In Italian)

At autopsy the internal carotid is found to be second only to the aorta in the frequency of arteriosclerotic changes. Current opinion, nevertheless, does not regard calcifications of the internal carotid among the common findings on skull roentgenograms. This discrepancy was investigated by comparing the radiographic and microscopic findings on anatomic specimens taken from 36 individuals ranging in age from forty to forty-five years. Definite (macroscopic) arteriosclerotic changes were found in 28 of the 36 specimens. Radiographic evidence of calcification was obtained in 9 of this number.

On skull roentgenograms from 1,483 ambulatory patients, there was evidence of internal carotid calcifications in 489 (32.9 per cent), though this was obvious in only about 50 (3.5 per cent). The incidence was greater in males (36.2 per cent) than in females (29.8 per cent), particularly in the forty- to fifty-year group; there was a noticeable increase in incidence with advancing age.

The cavernous portion of the internal carotid artery (from the carotid foramen to the dura) projects over the dorsum sellae, the cavum sellae, and a small portion of the sphenoid sinus, as seen on a lateral view of the skull. There is increasing tortuosity of the artery, which takes the aspect of two S's united end to end. The calcifications may be homogeneous, nodular, or striated, and both or only one of the internal carotids may become visible. As a rule, when the entire cavernous portion is seen, the track-like deposits start from the dorsum, curve through the cavum (inferior convexity), and cross toward the sphenoid sinus just below the anterior clinoids. On the frontal view, when extensively calcified, the internal carotid appears as two opaque rings, just lateral to the walls of the sphenoid sinus.

The differential diagnosis includes (1) calcified interclinoid ligaments, (2) hypertrophied mastoid cells projected over the cavum sellae, (3) hypophyseal calcifications, seldom demonstrable, (4) sellar and parasellar tumors, (5) bone sclerosis adjacent to the temporosphenoidal suture, (6) a thickened segment of the wall of the sphenoid sinus, and (7) calcified pachymeninges, *i.e.*, petro-clinoid ligaments at the base of the tentorium.

Forty-six roentgenograms; 1 drawing.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Hydatid Cysts of the Brain. Román Arana-Iñiguez and Jorge San Julián. J. Neurosurg. **12:** 323–335, July 1955.

It is stated that 2 per cent of all hydatid cysts are found in the brain. They are usually solitary and are many times more common in children than adults. The authors report 13 cases upon which they base their discussion of the clinical aspects.

The cysts are found most commonly in the parietotemporo-occipital region. Symptoms are not specific. In children, they include headache, vomiting, decreased visual acuity, somnolence, and convulsions. Objective signs are impairment of health, papilledema, optic atrophy, hemiparesis, tremor, and hypotonia. In adults the symptomatology corresponds to that of brain tumor.

Special diagnostic procedures include electroencephalography, with typical findings of an area of electrical silence surrounded by delta waves, and roentgenography. Radiographs may demonstrate thinning of the vault of the skull, progressing to the development of parchment-like diploe. Rarely, calcified hydatid cysts may be found.

Cerebral angiography has greatly facilitated the diagnosis of cerebral hydatid cysts. The authors mention several characteristic angiographic patterns, including complete absence of blood vessels within the lesion. The vessels surrounding the mass are not abnormal as with tumors, but parallel the cyst surface; they are not tortuous and have an even diameter throughout. These cysts attain a volume hardly ever exhibited by tumors so that displacement of vessels is enormous.

The authors repeatedly stress that ventriculography is contraindicated if hydatid cyst is suspected, because of the danger of puncturing the cyst and disseminating the process.

Treatment is surgical. The authors' 13 patients were operated on and all were alive at the time of the report.

Four roentgenograms; 5 photographs; 4 drawings; 3 diagrams.

PAUL C. HARDING, M.D.
Indiana University

Acoustic Neurofibroma. The Relationship of X-Ray Findings to the Otological Diagnosis. Francis O'N. Morris. Arch. Otolaryng. **62:** 18–27, July 1955.

This paper is presented to emphasize the fact that x-ray evidence of tumor formation may be lacking even in advanced cases of acoustic neurofibroma, and that surgical intervention in suspected cases should not be delayed if it is indicated by the clinical findings.

Nine cases of acoustic neurofibroma are summarized briefly, and 1 is reported in considerable detail. In 6 cases no abnormalities of the internal acoustic meatus of the skull were demonstrated roentgenologically; in all of these, x-ray examination included stereoroentgenograms of the skull and a projection in the Towne position. In each instance, however, surgical exploration led to the discovery of a tumor arising from the eighth nerve, which proved to be an acoustic neurofibroma. In 3 cases there was no roentgen evidence of erosion of the internal auditory meatus, but changes in the sella turcica indicative of increased intracranial pressure were observed.

The tenth case shows how attention may be directed away from the correct diagnosis of acoustic neurofibroma. Three and a half years before death the patient complained of deafness and tinnitus. A diagnosis of acute otitis media was made and a myringotomy was performed, but symptoms persisted. A year later, roentgen studies of the skull showed no abnormalities. In view of the negative x-ray report, the patient was treated for hypertension and the menopausal syndrome. Six months later x-ray examination was again negative except for mild cloudiness of the left mastoid process without cell destruction. One month before death roentgenograms (stereoroentgenograms, left lateral, postero-anterior, Law's and Mayer's views, and oblique views of the orbits) were taken and compared with previous films. The petrous pyramids appeared normal. The sella turcica was normal in size and configuration but showed slight demineralization of the posterior clinoid process. After neurosurgical consultation, the patient was scheduled for removal of a probable left acoustic neurofibroma, but she died the day before the operation was to take place. Necropsy revealed a vascular acoustic neurofibroma.

Three photographs.

Unusual Manifestations of Hyperparathyroidism. Leon Goldman. Surg., Gynec. & Obst. **100:** 675–689, June 1955.

Seven selected cases of hyperparathyroidism, with unusual manifestations which were deterrents to early diagnosis, are reported. This group of cases indicates that, in spite of unusual manifestations, the chemical findings are the common denominator in all and, when coupled with the clinical picture, are the most reliable signs in the diagnosis of hyperparathyroidism. Hypercalcemia is the most important of these chemical changes and requires extremely accurate determinations of the serum calcium level. Non-recognition or lack of consideration of hyperparathyroidism as a diagnostic possibility may cause prolonged delay in proper treatment.

The incidence of hyperparathyroidism as a cause of renal calculi is sufficient to warrant chemical studies in every case of nephrolithiasis. Local bone cysts, so-called giant-cell tumors—particularly of the mandible—or generalized skeletal demineralization may be the presenting symptom. Any one of these signs is an indication for chemical and further roentgenologic studies. Nausea, vomiting, and dehydration may simulate acute gastrointestinal disturbances.

The bone lesions heal following removal of the tumor or tumors, but the renal lesion is often progressive and, therefore, is most important in the prognosis. Renal insufficiency and hypertension are common sequelae.

Complete exploration of the thyroid area, the retrotracheal and retroesophageal areas, the anterior and posterior mediastinum, and the thyroid gland itself should be carried out in every case before removal of any tissue. Attempts should be made to visualize all normal parathyroid glands.

Signs of postoperative tetany occurred in every one of the author's patients when all hyperfunctioning tissue was removed. This is a welcome indication of complete ablation of all excess parathyroid tissue and should, therefore, be sought and confirmed before antitetanic therapy is started.

A clinically palpable nodule in the thyroid area in a patient with hyperparathyroidism usually turns out to be a thyroid nodule.

Eighteen roentgenograms; 4 photographs; 7 charts.

Some Aspects of Pantomography of the Mandible. Pekka Soila and Yrjö V. Paatero. Acta radiol. **44:** 21–24, July 1955.

Pantomography has been described in a number of papers (see, for example, Paatero: Acta radiol. **41:** 321, 1954. Abst. in Radiology **64:** 307, 1955; Fortschr. a. d. Geb. d. Röntgenstrahlen **82:** 525, 1955. Abst. in Radiology **66:** 310, 1956). It is a tomographic technic in which a curved film is exposed by means of a stationary x-ray tube while the part being examined takes a curvilinear course about a fixed axis. The film is arranged to move in constant relationship with the part being radiographed. Both sides of a curved object can thus be viewed on a single film with relatively slight distortion.

The authors found the mandible well suited to such a technic, owing to its parabolic form. The present report describes an experimental study on a dried mandible encased in a wire mesh. The extent of distortion and the depth of the image could be measured directly by the enclosing mesh. The results agreed well with the depth of image as calculated by the formula of Duhamel, who had previously analyzed the problem from a purely geometric point of view. Distortion was relatively slight, being maximal between the mandibular angle and the medial part of the bone. This can be reduced further by using eccentric pantomography, in which only half of the bone is examined at one time. The eccentric technic is especially helpful after abnormality is noted on the original view of the whole mandible. Stereoscopic films with this technic further improve evaluation of the structure.

Two roentgenograms; 1 drawing.

J. A. Gunn, M.D.
Grand Rapids, Mich.

Sialography. Carlos Coqui. Rev. mex. de radiol. **9:** 171–176, July-August 1955. (In Spanish)

The author describes the technic of sialography for demonstration of the parotid and submaxillary ducts and sets forth the indications for the procedure. After disinfection of the buccal mucosa, Lipiodol (40 per cent) is instilled through a blunt needle inserted in the open-

ing of the duct. The amount of the medium varies from 1.0 to 5.0 c.c., more being required for the parotid than for the submaxillary duct. Injection should be discontinued whenever it becomes painful.

Routine skull views are usually satisfactory, though oblique projections may be added. Lateral views of the parotid should be obtained with hyperextension of the neck, to avoid overlapping by the cervical spine. At least forty-eight hours must elapse between examinations of the two sides.

The following indications are listed: calculosis and other foreign bodies, stenosis of the ducts, salivary fistulas and diverticula, tumors, and certain inflammatory processes. The sole contraindication is acute infection.

Thirteen roentgenograms.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Chronic "Sialectatic" Parotitis in the Light of Pathological Studies on Parotidectomy Material. David H. Patey and A. C. Thackray. Brit. J. Surg. **43:** 43–50, July 1955.

Chronic parotitis presenting with intermittent swelling of one or both parotid glands is a well recognized entity. There may be an obvious cause, such as obstruction by a calculus, but the etiology is usually obscure. Infection, obstruction with secondary infection, and congenital sialectasis have been suggested. Clinically, differentiation from a tumor may be impossible and even on biopsy a mistaken diagnosis of tumor is not infrequently made.

The authors report 9 cases of chronic "sialectatic" parotitis, 8 of which were treated by total, subtotal, or extensive partial conservative parotidectomy. Three of these cases were typical examples of the inflammatory-obstructive type. Four cases were at first diagnosed clinically as neoplasms, but final microscopic study revealed a chronic parotitis. Two of the 9 cases were thought clinically to be intermediate in type between the inflammatory-obstructive group and the tumor-simulating group.

Calculi in the parotid area are rarely identified by x-ray, although occasionally multiple microcalculi are found in the intermediate-sized ducts on pathological examination and may sometimes be identified on radiography of the operative specimen. The most characteristic radiologic finding in chronic parotitis is the so-called "sialectasis," involving chiefly the intermediate and smaller ducts, and demonstrable by sialography. The authors contend, however, that though dilatation of the intralobular ducts does exist, the main cause of the typical "sialectatic" picture is extravasation of the Lipiodol interstitially. This would explain the other characteristic sialographic feature of chronic parotitis, namely, the tendency of Lipiodol to remain in the gland. In several cases of their series residual Lipiodol was demonstrated weeks, months, and sometimes even years after sialography.

These radiologic findings are common to all types of chronic parotitis irrespective of the clinical picture. When the inflammatory process is advanced, the glandular substance may either be replaced by large masses of lymphoid tissue or obliterated by hyperplastic changes in the epithelium of the ducts. This results in large filling defects in the pattern of the ductal system.

The authors conclude that chronic parotitis may present clinically either as an inflammatory-obstructive pattern or as a tumor-simulating pattern. In both, the pathologic picture is one of chronic inflammation differing in degree and distribution. In both, the radiologic picture is that of a glandular sialectasis.

The fragmentation of the connective-tissue walls of the intralobular ducts may be more significant than merely allowing extravasation of Lipiodol during sialography. It is possible that the normal secretion of the gland may also leak through the weakened wall, providing a persistent or recurrent irritative factor.

Three roentgenograms; 3 photographs; 6 photomicrographs.

JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

THE CHEST

The Place of Lateral Tomography in the Study of Lesions of the Intrathoracic Respiratory System. E. Forster, D. Sichel, H. Blum, and Roegel. J. de radiol. et d'électrol. **36:** 485–503, 1955. (In French)

Lateral tomography may permit more strict segmental localization of pulmonary lesions, not only by the general placement of the lesion but also by depicting its relation to pleural fissures. At times cavities are shown more clearly than on plain roentgenograms or on anterior-posterior tomograms. The extent of pleural thickening in the vicinity of the lesion is demonstrated, and this may be of value to the surgeon. Bronchial drainage and deformities of the bronchi may be better visualized.

Fifty-one roentgenograms; 1 photograph; 1 drawing.

CHARLES M. NICE, JR., M.D.
University of Minnesota

Bronchography in the Study of Cavities Following Thoracoplasty. Elio Sada. Radiol. med. (Milan) **41:** 662–676, July 1955. (In Italian)

Radiolucent areas in a lung collapsed by thoracoplasty can be demonstrated by standard and/or body-section radiography, but differentiation of residual cavities from bronchiectases is always difficult. For this purpose the author recommends bronchography through a Métras (opaque) catheter, introduced into the segmental bronchus. Although irritating and less radiopaque than oily media, water-soluble Joduron B was used in a series of about 40 patients, major emphasis being placed upon complete disappearance of the contrast material from the lung field after the procedure.

In the average case, about 10 c.c. of the medium was sufficient for visualization of the portion of lung under consideration. In addition to the frontal view and upright, oblique, and lateral projections, sometimes with a spot-film device, body-section roentgenograms are occasionally helpful for evaluation of the draining bronchus or to demonstrate eventual bronchopleural fistulous tracts. Preoperative and postoperative comparison and follow-up studies are of value in special cases. The pitfalls of this method are also discussed, as well as certain maneuvers to fill cavities in difficult (apical) locations.

Commenting on the still widely accepted view that bronchography is contraindicated in tuberculosis, the author refers to over 100 bronchographic studies performed by himself in a tuberculosis sanatorium, with only one complication (kidney damage in a patient with amyloidosis from long-standing empyema).

Twenty-three roentgenograms.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Technique of Bronchography. S. W. French, III. J. Thoracic Surg. **30**: 111–113, July 1955.

Line drawings are reproduced, illustrating the various positions which the author has used for several years in bronchography. He states that the method is simple, can be performed quickly without the aid of fluoroscopy, and that excellent bronchograms are uniformly obtained.

Pulmonary Manifestations of Systemic Diseases. Eli H. Rubin. Am. J. Surg. **90**: 50–62, July 1955.

The lungs may be thought of as a mirror of what is going on in organs and tissues of the body not accessible to direct examination. The author groups diseases affecting the lungs and appendages into three major categories: (1) primary diseases, which include developmental defects, new growths, traumatic injuries, and similar conditions; (2) secondary diseases, which include pulmonary emboli, metastatic cancer, and so-called "terminal" pneumonias; (3) concomitant diseases in which the respiratory tract is involved either initially or in the course of systemic diseases as an active, more or less, co-equal participant.

In general, when the lungs are involved as part of a systemic disease, the following are noteworthy: (1) a symmetric distribution of lesions in both organs, (2) a vascular or perivascular pattern of abnormal lung markings, and (3) a tendency toward pleural implication.

A very brief discussion in outline form of a limited number of the diseases in the third category is given. Little more than a list of them can be given here.

Metabolic diseases may involve the lungs through structural damage and by providing conditions favoring infection. The following diseases are discussed: pulmonary infection in the diabetic, cystic fibrosis of the pancreas, histiocytosis, amyloidosis of the lungs, and metastatic calcification.

Diseases of the blood and blood-forming organs seldom affect the lungs, but there are occasionally bizarre blood findings in association with intrathoracic conditions. Sickle-cell anemia, pulmonary hemosiderosis, polycythemia, hemorrhagic diseases, and infectious mononucleosis are discussed.

Under *diseases of hypersensitivity* are grouped transitory pulmonary infiltrations and eosinophilia, severe and protracted forms of pulmonary infiltrations and eosinophilia, polyarteritis nodosa, rheumatic pneumonia, and rheumatoid disease with pulmonary lesions.

Diseases of the skin and mucous membranes considered are allergic dermatitis, erythema multiforme, erythema nodosum, systemic lupus erythematosus, mycosis fungoides, neurocutaneous diseases, scleroderma, dermatomyositis, acanthosis nigricans, and sarcoidosis. Several pleuropulmonary manifestations of abdominal diseases are also included.

Twenty roentgenograms; 2 photographs.

HOWARD NEUCKS, M.D.
Indiana University

Pulmonary Roentgenologic Changes in the Collagen Diseases. L. H. Garland and M. A. Sisson. Am. J. Surg. **90**: 63–76, July 1955.

The authors include periarteritis nodosa, acute disseminated lupus erythematosus, dermatomyositis, scleroderma, rheumatic fever, and rheumatoid arthritis as the accepted collagen diseases. A brief discussion of their etiology and pathology is presented.

The pulmonary changes of periarteritis (or polyarteritis) nodosa and scleroderma are similar, consisting of nodulation, increased linear markings, and/or edema. The edema may be localized or diffuse. Scleroderma may show subpleural or basilar cystic disease and calcinosis as well.

In periarteritis nodosa, as well as in acute disseminated lupus erythematosus, cardiac enlargement with or without pericardial effusion and pleural effusion are common. In scleroderma, there is often a decreased amplitude of cardiac pulsation, but the heart may be small, normal, or large. The other, more familiar, changes of scleroderma in the phalanges and soft tissues are mentioned. The gastrointestinal changes generally consist of decreased peristalsis and dilatation of the lumen of any segment of the bowel. At times the esophagus may show narrowing at its distal end or shortening.

Rheumatic pneumonitis may occur in rheumatic fever but produces no specific radiographic picture. Rheumatic pericarditis is not uncommon. Rheumatoid arthritis rarely presents pneumonitis or pleuritis. In rheumatoid arthritis in children (Still's disease), pericarditis may be seen. Little is known about the radiographic findings in dermatomyositis.

Twenty-eight roentgenograms; 3 tables.

W. DONALD JANNEY, M.D.
Indiana University

Lung Lesions in Rheumatoid Arthritis. A. Aronoff, E. G. L. Bywaters, and G. R. Fearnley. Brit. M. J. **2**: 228–232, July 23, 1955.

Chest films of 130 patients with rheumatoid arthritis were compared with an equal number from patients without arthritis, in an attempt to see if such an entity as "the rheumatoid lung syndrome" exists. A comparative study was also made of 42 autopsy specimens from persons with rheumatoid arthritis and a control series of equal size.

No specific lung lesion was found to be associated with rheumatoid arthritis, although the incidence of some non-specific lesions (emphysema, pleural thickening, bronchitis, etc.) was higher than among the controls. Neither was any correlation found between episodes of pulmonary infection and flare-ups of the arthritis.

Four cases of unusual lung conditions unrelated to arthritis are reported in detail, but in only 1 was a final diagnosis available, namely, carcinoma.

Six roentgenograms; 3 tables.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Intrapulmonary Septal Lymphatic Lines (B Lines of Kerley). Their Significance and Their Prognostic Evaluation Before Mitral Valvotomy. Ronald G. Grainger and John B. Hearn. J. Fac. Radiologists **7**: 66–76, July 1955.

Intrapulmonary septal lymphatic lines, sometimes called "B" lines, are multiple short (1–3 cm.) horizontal lung markings seen on chest films in the costophrenic angle regions. They are usually bilateral, non-branching, and sharply defined, numbering 4 to 6 on either side. This review of 134 patients who underwent cardiotomy for mitral disease was made in an attempt to relate these lines to pulmonary vascular pressure and degree of disability, and also to evaluate their significance in mitral disease.

It is fairly certain that distention of interlobular

septal lymphatics causes B lines. Any condition leading to impaired centripetal lymphatic drainage in the lungs may give rise to these markings and, in any condition which is reversible, they may disappear within a short time after their cause has been removed. They have been observed in lymphangitic carcinomatosis, Hodgkin's disease, leukemia, mediastinal reticulosis, pneumoconiosis and sarcoidosis, and in heart disease, especially mitral disease. In the latter condition there is increased transudation of fluid from the pulmonary capillaries into the pulmonary stroma. This causes edema of the septa and distention of their draining lymphatic vessels. In this connection, the authors demonstrated no relation between effort disability and pulmonary vascular pressures in mitral disease, nor between the effort disability in mitral disease and the presence or absence of B lines.

Whereas minor x-ray changes in the pulmonary arteries are somewhat difficult to evaluate radiographically, the B lines can be diagnosed with much less experience and with less error.

Their presence in mitral stenosis has a certain prognostic significance, in that these patients almost invariably improve after valvotomy.

Seven roentgenograms; 4 figures.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Pulmonary Ossification in Patients with Mitral Stenosis. W. Whitaker, A. Black, and A. J. N. Warrack. J. Fac. Radiologists **7**: 29–34, July 1955.

Multiple calcified pulmonary nodules occurring in 7 patients with mitral stenosis are here described. These small intra-alveolar bony nodules were found to be more numerous in the right lung, especially in its lower portion. There were also x-ray evidence indicative of pulmonary hypertension and a soft mottling consistent with hemosiderosis.

The occurrence of hemosiderosis in association with the bony nodules suggests that both are probably somehow related to abnormally high pulmonary vascular pressures. It has been proposed that hemosiderosis results from recurrent small vascular hemorrhages, while pulmonary ossification occurs in the fibrinous exudate of pulmonary edema (Lendrum, Scott, and Park: Quart J. Med. **19**: 249, 1950). However, since pulmonary hypertension is common in mitral stenosis, whereas pulmonary ossification is not, other factors must be involved. Only 2 patients in this series had symptoms suggesting left ventricular failure, which would seem to indicate that, if edema is a factor, it must be a localized rather than a generalized form.

Eight roentgenograms; 1 photomicrograph; 1 photograph; 1 table. DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Bilateral Hilar Adenopathy: Its Significance and Management. Corrin H. Hodgson, Arthur M. Olsen, and C. Allen Good. Ann. Int. Med. **43**: 83–99, July 1955.

Bilateral hilar adenopathy has been reported in association with sarcoidosis, the lymphomas, erythema nodosum, metastatic malignant disease, pneumoconiosis, coccidioidomycosis, histoplasmosis, tuberculosis (usually the adenopathy is unilateral in this disease), BCG vaccination, lymphogranuloma venereum, secondary syphilis, and fibrocystic disease of the pancreas. In the authors' series, which they state is not subject to statistical evaluation because of their mode of selection of cases, the differential diagnosis seems to have been chiefly between sarcoidosis, lymphoma, and an indeterminate group. The indeterminate group numbered 46 cases; there were 44 patients with proved sarcoidosis and 11 with lymphoma. In addition, there were 6 cases of metastatic cancer and isolated instances of tuberculosis, silicosis, and fibrocystic disease of the pancreas.

Roentgen findings are not a satisfactory basis for differentiation between the various groups in so far as the bilateral hilar adenopathy itself is concerned. Other diagnostic procedures, such as blood counts, skin tests, culture of material recovered from the stomach, bronchi, pleura, and sputum, cytologic examination of body fluids, and particularly biopsy of accessible nodes, sternum, liver, or lesions in the skin or elsewhere, are essential. Bronchoscopy is ordinarily not indicated.

The use of irradiation as an aid to diagnosis is deplored. The authors point out that benign forms of hilar adenopathy may resolve spontaneously coincident with a course of roentgen therapy, the patient then being unjustifiably labeled with the diagnosis of Hodgkin's disease or lymphoma.

In the 44 cases of sarcoidosis, an outstanding characteristic was the apparent good health of the patients, in striking contrast with the lymphoma group.

The authors also discuss the association of erythema nodosum with bilateral hilar adenopathy. Although they are frequently associated, it is not believed that they constitute a specific entity. When associated with erythema nodosum, the adenopathy is unlikely to be attributable to malignant disease.

Ten roentgenograms. RICHARD G. LESTER, M.D.
University of Minnesota

Localized Bronchiectasis Simulating Pulmonary Neoplasms. Benjamin Schwartz and Harry L. Katz. Ann. Int. Med. **43**: 45–60, July 1955.

A localized area of bronchiectasis, when filled with secretions and surrounded by an area of pneumonitis, may present as a circumscribed rounded shadow on the conventional chest film. Such a patient may be completely or relatively asymptomatic, and the lesion may be discovered only on routine study. In this case the appearance may simulate tumor, either a peripheral carcinoma or a benign neoplasm. Four of 6 cases seen by the authors are reported. They point out that the usual procedures in such a case, including bronchoscopy with cytologic study of the washings, examinations of sputum and gastric secretion, and skin tests will be unrewarding, with the diagnosis still in doubt.

On the other hand, bronchography will often reveal the nature of the lesion, and will also demonstrate the extent of the bronchiectasis, thus determining if surgery is feasible. This procedure, which is often neglected during work-up for a "coin lesion," may obviate the necessity for an exploratory thoracotomy and should be a part of the study of all patients with an isolated and unexplained pulmonary lesion.

Six roentgenograms; 3 photomicrographs.

RICHARD G. LESTER, M.D.
University of Minnesota

Pulmonary Hamartoma, an Enlarging Neoplasm. Wilson Weisel, Marvin Glicklich, and Francis B. Landis. Arch. Surg. **71**: 128–135, July 1955.

Pulmonary hamartomas have been considered rela-

tively stable or, at most, very slowly progressive lesions. The authors present 10 selected cases of pulmonary hamartoma in which visible growth was a significant feature. In 9 instances the possibility of carcinoma was considered before the diagnosis was established pathologically. This illustrates the hazard of a differential diagnosis based upon the stability or instability of a lesion's size. Calcification was found roentgenologically in only 1 case, so that its absence is without diagnostic significance.

In none of the 10 cases were lymph node metastasis, multiple tumors, or recurrences encountered. The case histories, roentgen findings, and pathologic observations are presented in some detail.

Sixteen roentgenograms; 4 photomicrographs; 1 photograph.

JOHN W. WILSON, M.D.
University of Texas, Dallas

Symptomatology and Radiology in Pneumoconiosis. A Survey in the Durham Coalfield. D. J. Newell and R. C. Browne. J. Fac. Radiologists **7**: 20–28, July 1955.

A survey of the work histories and respiratory symptoms of 5,117 coal miners was conducted by the authors in conjunction with a chest x-ray survey in Great Britain. The object was to determine the relationship between radiological evidence of pneumoconiosis and its symptoms. Reading and classification according to standard radiological categories for pneumoconiosis were done by three viewers, each without knowledge of occupational or physical histories of the subjects.

The most notable conclusion afforded by the investigation is the apparent lack of relationship between radiological findings and respiratory status. Many men who have no symptoms may be classified as having radiological pneumoconiosis, while many who are disabled show no abnormality roentgenographically.

The proportion of faceworkers who have symptoms is greater than that of other employees of the same age. This proportion, however, appears to increase with age without relation to the number of years of facework.

On the basis of this study it appears that radiological pneumoconiosis is not a disabling disease, but that the disability of coalface workers may be due to other chest disease which does not manifest itself radiographically.

Three figures; 4 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Pneumoconiosis on the Kolar Gold Field, South India. Geoffrey E. Ffrench. Arch. Indust. Health **12**: 73–82, July 1955.

Pneumoconiosis had been a compensable condition in the Kolar Gold Field (Mysore State, South India) since 1940. Although there may be considerable dust retention within the lungs of underground workers after a period of ten to fifteen years, little disability is encountered. Experimental studies have indicated that the relatively high aluminum oxide content of the airborne dust may account for the relative harmlessness of the condition. The potential danger is in the association of tuberculosis with the pneumoconiosis.

Three stages of pneumoconiosis are recognized: (1) anteprimary—radiological evidence only, without disability; (2) primary—radiological evidence, with symptoms causing incomplete disability; (3) secondary—radiological evidence of pneumoconiosis, with clinical and radiological findings of active tuberculosis and/or complete disability. During the years 1948 to 1951, inclusive, 13,915 workers were examined; 251 were found to have anteprimary pneumoconiosis, 61 primary pneumoconiosis, and 80 secondary pneumoconiosis.

Radiological Diagnosis: In the *prepneumoconiotic stage*, a fine reticulation becomes demonstrable in the right mid zone, with small ring-like shadows from 2 to 5 mm. in diameter, at first vague in outline but later more discrete and smaller. The underlying reticulation may be mistaken for mere haziness unless carefully examined. This stage does not denote a sufficient degree of dust reaction to be designated as pneumoconiosis, but is rather an alteration in the fine appearances of the lung through dust retention. The finding of increased hilar shadowing and radiating lung markings is not consistent, though these are present more often than not. The fine reticulation is succeeded by very *small discrete, annular, and punctate shadows*, 1 to 3 mm. in diameter, and even smaller. The annular shadows predominate. They begin in the right mid zone, occur later in the left mid zone, and spread to peripheries, bases, and, after many years of exposure, to the apices.

In both the above stages, the linear markings of the lung parenchyma continue to be visible, together with the specific changes, and this is regarded as fundamental when assessing the degree of pneumoconiosis.

The next stage is that of *discrete mottling affecting the entire lung fields*. The shadows are more numerous and slightly larger, and only the heaviest lung markings are seen; the picture is that usually described by the term "ground glass."

Diffuse consolidated shadows are indicative of active tuberculous infection, which may obscure the underlying pneumoconiosis.

The relationship of pneumoconiosis to tuberculosis is discussed. It is only when the two conditions occur together that life expectancy is shortened.

Three roentgenograms; 5 photomicrographs; 1 photograph; 2 tables.

Talc Pneumoconiosis. Morris Kleinfeld, Jacqueline Messite, and Irving R. Tabershaw. Arch. Indust. Health **12**: 66–72, July 1955.

The health status of a group of 32 talc workers, whose roentgenograms and histories were available after fourteen years, has been appraised by the authors. These cases were reported originally by Siegal *et al.* (Am. J. Roentgenol. **49**: 11, 1943. Abst. in Radiology **41**: 199, 1943). Nineteen of the group had died, at ages ranging from forty-eight to eighty-four years. In 4 death was believed to be due to pulmonary failure associated with talc pneumoconiosis. In general, the workers appeared well developed and well nourished in contrast to the earlier observations. No reason can be offered to explain this apparent difference. Six of the workers were still actively employed.

Clinically, the outstanding features were dyspnea, productive cough, abnormal chest findings (diminished breath sounds, basal râles, limited chest expansion), and clubbing. The findings in the chest roentgenograms were of particular interest. The basic lesion was an interstitial infiltration of variable intensity, located basally and in the mid-lung fields, and of bilateral distribution, with the apices relatively spared. In several, the infiltration was of nodular character. Emphysematous bullae of varying size were observed in 4 cases. A striking finding was the presence of opaque densities, varying from single linear strands in

the region of the diaphragm to massive deposits, bizarre in shape, extending over a large part of the lung and occasionally on the pericardium. These deposits, referred to as talc plaques by Siegal *et al.*, were demonstrable in all but 1 of the cases. When comparison was made with the roentgenograms taken in 1941, it was of interest to note that, although variable progression occurred in the majority of cases, what in retrospect appeared to be severe pulmonary involvement in the original films could not be so considered in the light of a fourteen-year interval. Furthermore, the hilar adenopathy which was seen in 6 of the 1954 roentgenograms was also visible in 3 of the roentgenograms taken in 1941. Cardiac enlargement was found in 4 persons; in 2 the cardiac configuration was suggestive of cor pulmonale. A marked decrease in the cardiac silhouette was noted in 1 patient and a strongly suggestive decrease in another. It is possible that pleural pericardial adhesions, associated with the plaque formation, and subsequent retraction and limitation of the pericardium may account for this decrease. No correlation between symptomatology and the x-ray findings was observed.

In 6 of 11 patients an abnormal electrocardiographic pattern was found; 2 showed right ventricular hypertrophy, 2 left ventricular hypertrophy, 1 an abnormal rhythm, and 1 non specific T-wave alterations. The 2 patients with right ventricular hypertrophy had other findings suggestive of cor pulmonale.

The peripheral blood findings were not remarkable and did not reflect the physiopathologic changes associated with talc pneumoconiosis.

The marked improvement in engineering methods, instituted between 1943 and 1948, was reflected in an appreciable decrease in dust exposure. The pathological picture, however, did not retrogress with improvement of the industrial environment or upon retirement.

Six roentgenograms; 3 tables.

Thiopneumoconiosis of "Kovand" Workers. B. Bugyi. Fortschr. a. d. Geb. d. Röntgenstrahlen **83**: 40–42, July 1955. (In German)

Pulmonary fibrosis, resulting from inhalation of "elementary" sulfur dust in Sicilian mines, was first described by Italian authors. This occupational condition, called thiopneumoconiosis, does not threaten those who work with dust from "melted" sulfur.

The author reports his findings in 9 workers from a *Kovand* mill (part of a sulfuric acid factory in Hungary) which uses as raw material a mineral with a high content of "elementary" sulfur.

The clinical symptomatology in those affected included cough, colorless and gelatinous expectoration, and moderate to severe dyspnea. The chest roentgenograms revealed one or more of the following findings: juxtahilar infiltration, micronodulation, and interstitial fibrosis.

Three roentgenograms. E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Beryllium Poisoning (Beryllosis). X-Ray Manifestations and Advances in Treatment. H. E. Tebrock. Am. J. Surg. **90**: 120–121, July 1955.

The author presents a general discussion of beryllium poisoning, which he describes as "a general disease characterized clinically by pulmonary insufficiency and having the major pathologic changes in the lungs." Essential to the diagnosis are (1) a history of exposure to beryllium compounds; (2) a characteristic type of onset and clinical course; (3) radiologic and (4) laboratory findings consistent with the disease; (5) demonstration of beryllium in the tissues or urine. The biopsy findings resemble sarcoidosis so closely that differentiation on this basis alone may not be possible.

The radiologic picture in the early stage of the chronic disease consists in a diffuse, finely granular haziness and some degree of obscuration of the pulmonary markings, with sparing of the apices and extreme bases, where there may be a compensatory emphysema. Later a reticular pattern is superimposed, followed by nodulation, up to 5 mm. in diameter, without cavitation, calcification, or coalescence, producing the appearance of a large-flake snow storm. At this stage signs of cor pulmonale may develop.

Treatment in severe cases requires bed rest and oxygen. Cortisone affords dramatic relief of symptoms but regression follows its withdrawal. Research is being carried out with a chelating agent, ATA (aurin tricarboxylic acid) to filter out the beryllium or prevent further damage by it. This has not been used extensively as yet.

GEORGE C. WERNER, M.D.
Indiana University

Miliary Calcification of the Lungs after Treated Miliary Tuberculosis. Sol Katz, James Stanton, and George McCormick. New England J. Med. **253**: 135–137, July 28, 1955.

The authors present 2 cases with clinical and laboratory evidence of miliary tuberculosis in which roentgenograms taken after recovery showed miliary calcification.

The first patient was a woman of twenty-five who was successfully treated with streptomycin and PAS. Chest films on discharge from the hospital showed a diffuse stippling infiltration of both lung fields. Later, bilateral miliary lesions containing minute calcific flecks were demonstrated. In the second patient, a 28-year-old Negro, the pulmonary disease was complicated by bilateral pleural effusions, cold abscesses, and tuberculosis of the lumbar and cervical vertebrae. Immobilization, streptomycin, and PAS therapy resulted in fusion of affected vertebrae and eventual recovery from the acute process. Films of this case five years later showed miliary calcification.

With better antituberculosis therapy, acute miliary tuberculosis, formerly fatal, can be expected to respond favorably in 90 per cent of cases, with healing of the lesions and subsequent miliary calcifications in some instances.

Five roentgenograms.

HILTON RODRIGUEZ DELGADO, M.D.
Mercy Hospital, Pittsburgh

THE CARDIOVASCULAR SYSTEM

Blood Volume and Residual Volume of the Heart in Decompensation. Gustav Nylin. Am. Heart J. **49**: 803–822, June 1955.

The author studied the blood volume in 55 cases of cardiac decompensation using red cells tagged with radioactive P^{32} and thorium B, injected intravenously. Both vascular and valvular heart disease were included. Generally speaking, the red cell volume was higher in decompensated than in control cases, higher in decompensated than in compensated cases, higher in men than in women, and higher in valvular than in vascular heart dis-

ease. The history of cardiac congestion varied from three and a half to twelve years. In the group with valvular heart disease, the total red cell volume was almost normal when the insufficiency was of fairly short duration, but gradually increased as decompensation became more prolonged. The plasma volume was also increased in the decompensated cases.

In decompensation the bone marrow shows a comparatively greater percentage of nucleated red cells than normal; this may be due to the anoxia plus some endocrine factor.

The author also used heart measurements for the determination of cardiac blood volume: $V = 0.38 \times l \times m \times n$ where l represents the length of the heart in the posteroanterior view at 2 meters, m represents the breadth of the heart in a similar view, and n is the cardiac diameter in a lateral projection at 1.5 meters. From this formula indirect information is gathered regarding residual blood volume. Because of the changes following treatment, with a reduction in the cardiac volume, it is considered probable that the large residual of blood in the heart is responsible for the increased red cell volume during decompensation.

Fourteen roentgenograms; 2 photographs; 10 graphs; 1 drawing; 7 tables.

HENRY K. TAYLOR, M.D.
New York, N. Y.

Eisenmenger's Complex. James W. Brown, Donald Heath, and William Whitaker. Brit. Heart J. **17:** 273–284, July 1955.

Eisenmenger's complex of ventricular septal defect with dextroposition of the aorta without pulmonary stenosis blends anatomically and clinically with transposition of the great vessels on the one hand and high ventricular septal defect associated with pulmonary hypertension on the other. The symptoms and signs in Eisenmenger's complex are nearly all due to pulmonary hypertension. The dominant symptom in the authors' series of 7 cases was progressive breathlessness. Cyanosis was present in all. Occasional symptoms were cough, hemoptysis, syncopal attacks, and dizziness. With a single exception, all the patients showed right ventricular enlargement roentgenologically. The pulmonary artery and its branches were prominent in every instance, but in only 4 patients did they show increased pulsations fluoroscopically. Angiocardiography in each case demonstrated the overriding aorta by simultaneous filling of the pulmonary artery and aorta from the right ventricle. Six of the 7 patients were catheterized and high pulmonary artery pressure was demonstrated.

Electrocardiograms showed right ventricular dominance in all but 1 patient, who also had systemic hypertension.

In differential diagnosis the important points are the onset of cyanosis and dyspnea (usually during adolescence), x-ray and/or electrocardiographic evidence of right ventricular enlargement, the simultaneous filling of the aorta and pulmonary artery from the right ventricle, and catheter demonstration of high pulmonary artery pressure.

Histologically the pulmonary arteries show intimal proliferation and hypertrophy of the media.

Eight roentgenograms; 2 photomicrographs; 2 photographs; 1 electrocardiograph; 3 tables.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Right Aortic Arch Versus Mediastinal Tumors and Densities: Diagnostic Problems. Emanuel Schwartz and Henry H. Kalter. Dis. of Chest **28:** 91–97, July 1955.

The authors report 4 cases of right aortic arch with left descending aorta, showing typical displacement of the esophagus anteriorly and to the left, with the aortic knob on the right side of the superior mediastinum. Three additional cases, superficially similar on the plain films, are also presented to illustrate problems in differential diagnosis. In 2 of these enlarged mediastinal nodes bulging to the right simulated a right aortic arch; in the other patient a double-lobed upper mediastinal density proved to be due, in its right upper part, to the manubrium sterni.

Twelve roentgenograms. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Aneurysmal Dilatation of Aortic Sinuses in Arachnodactyly: Diagnosis During Life in Three Cases. Israel Steinberg and William Geller. Ann. Int. Med. **43:** 120–132, July 1955.

The incidence of cardiovascular abnormalities in arachnodactyly is estimated at 30 to 60 per cent. Clinically, the lesion is usually in the aorta and may consist of a saccular or fusiform aneurysm, a generalized dilatation of the aorta, or a dilated aortic ring. More rarely intracardiac lesions, valvular or mural, are present.

Aneurysmal dilatation of the aortic sinuses is rare and because of their intracardiac position the diagnosis is seldom made *in vivo*. The authors report 3 cases of arachnodactyly in which angiocardiography revealed distinct dilatation of the aortic sinuses. In none of the cases was this demonstrated on conventional films, although 2 of the patients showed distinct left ventricular enlargement, and 1 showed unusually active pulsations at the root of the aorta.

The cause of the aortic sinus dilatation in this disease is a degenerative change in the media. Its demonstration is of grave prognostic significance, as rupture may occur at the weakened point or aortic ring incompetence and intractable heart failure may result.

Nine roentgenograms; 3 tracings.

RICHARD G. LESTER, M.D.
University of Minnesota

The Pulmonary Vessels in Congenital and Acquired Heart Disease. Normal and Pathological Variations on Body-Section Roentgenograms. Th. Hornykiewytsch and H. St. Stender. Fortschr. a. d. Geb. d. Röntgenstrahlen **83:** 26–40, July 1955. (In German)

Arteries and veins can be identified on body-section roentgenograms of the lungs (without injection of contrast material). Four aspects may be encountered in *congenital heart disease*: (1) Dilated arteries and veins are seen whenever a left-to-right shunt increases the pulmonary vascular volume, as in interatrial septal defect, Lutembacher's syndrome, patent ductus arteriosus, interventricular septal defect, transposition of pulmonary veins, and rarely in Eisenmenger's complex. (2) Dilated arteries with narrowed or unchanged veins indicate an increase in pulmonary arteriolar resistance, such as occurs in transposition of the great vessels and Eisenmenger's complex. This causal relationship is very constant; thus, dilated veins due to conditions listed in the first group may undergo narrowing if in a subsequent stage of the disease the pulmonary resist-

ance reaches high levels. (3) Narrowed arteries and veins result from pulmonary stenosis (valvular or infundibular, as part of a tetralogy or pentalogy), even in the presence of post-stenotic dilatation. Narrowing may also be due to congenital hypoplasia. (4) The pulmonary vessels may remain unchanged despite the presence of congenital heart disease.

In *acquired heart disease*, central stasis (involving the hili, and the upper and middle lung fields) is seen almost exclusively in mitral stenosis, while peripheral stasis (small hili, congested lung bases) accompanies aortic pathology, *i.e.*, decompensated hypertensive heart disease, aortic stenosis, and incompetence, etc. In the presence of mitral disease, body-section roentgenograms of the lungs may demonstrate dilated veins and narrowed or unchanged arteries when incompetence is the predominant feature, while dilated arteries and narrow veins accompany mitral stenosis once it has reached the stage of enlarged atrium with increased pulmonary pressure. In aortic disease, changes in the pulmonary vessels appear only if and when left ventricular failure is followed by stasis in the left atrium and pulmonary veins; under these circumstances the lung root veins will be dilated and the arteries remain unchanged, though after a long-standing process even the arteries may become widened.

The relationship between the condition of the pulmonary vessels and the cardiovascular status, as summarized above, should not be construed as a set of hard and fast rules, but only as a suggestive finding, in need of additional proof for final confirmation of the diagnosis.

Fifteen roentgenograms. E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Pulmonary Stenosis with Increased Pulmonary Blood Flow. Frederic L. Eldridge and Herbert N. Hultgren. Am. Heart J. **49:** 838–861, June 1955.

The authors studied 8 cases of pulmonary stenosis with increased pulmonary blood flow, all with left-to-right shunts. Four had interventricular septal defects, 3 had interatrial septal defects, and 1 had an aortic-pulmonary artery communication. The case histories, including the findings on cardiac catheterization, are given. All patients had increased blood in the lungs and right ventricular enlargement; 5 showed prominent pulmonary artery segments, 1 a hilar dance, and another considerable pulsation of the pulmonary vessels. Five had hypoplastic aortas, 1 a right-sided aortic arch, and 1 situs inversus. The commonest defects associated with increased pulmonary flow are interatrial and interventricular septal defects, even in the presence of a pulmonic stenosis. Surgical closure of the septal defect, and advisability or non-advisability of subsequent valvotomy are discussed.

The authors studied 3 additional cases after submitting the original paper for publication, each of which showed an interatrial septal defect.

Twelve roentgenograms; 8 electrocardiograms; 8 pressure tracings; 1 chart; 11 tables.

HENRY K. TAYLOR, M.D.
New York, N. Y.

Micro-Angiography in the Study of Hepatic Circulation. J. Mirabeau Cruz and Ayres de Sousa. Gaz. méd. portuguesa **8:** 449–460, July-August 1955. (In Portuguese)

The authors' technic of microangiography as used in experimental studies of the hepatic circulation comprises the following steps: (1) injection of Thorotrast into the portal vein or hepatic artery of rabbits; (2) sacrifice of the animal and fixation of the liver for forty-eight hours in alcohol or formol; (3) preparation of frozen sections, sandwiched between two slides of plastic material of low x-ray absorption; (4) roentgenography of these sections with grenz-ray transformer, 1 mm. focal spot (rotating anode), beryllium-window tube, on special fine-grain film.

The findings substantiated the existence of many intrahepatic (but no extrahepatic) connections between the portal and hepatic venous systems. The hepatic arterioles were seen to send branches to the walls of the biliary channels, to portal vessels (arteriovenous anastomoses), and to the central and peripheral sinusoids of the hepatic lobule. The value of microangioroentgenography is well demonstrated in the functional and histologic evaluation of organs from laboratory animals.

Twenty-nine microroentgenograms.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Injector for Aortography. W. Barr Stirling. Lancet **2:** 123, July 16, 1955.

An apparatus for the rapid introduction of the opaque medium in aortography is described. It embodies the simple principle of vertical lever action and is under complete manual control. In practice 18 to 20 ml. of contrast medium is injected in not more than a second, with a pressure of 800 mm. Hg. In the author's opinion this is not excessive when compared with a pressure of 500 mm. Hg over three to four seconds when injection is made by hand. Excessive pressures—over 2,000 mm. Hg—produced by some gas-air machines are unnecessary and dangerous. The author's apparatus has been used in over 100 cases with excellent results.

One roentgenogram; 1 drawing.

Fractionation Technique in Translumbar Aortography and Femoral Arteriography. Martin Langsam, Alexander Lewitan, Louis Nathanson, and David Wilensky. Arch. Surg. **71:** 120–123, July 1955.

With advancing developments in vascular surgery, a renewed interest in arteriography has emerged. The need is stressed for an arteriographic technic in which serial films can be made, simultaneously visualizing the aorta, the femoral artery, and its lower extremity branches. The authors have devised a procedure which can be carried out without expensive or unusual equipment.

Sodium acetrizoate (Urokon Sodium) 70 per cent is the opaque medium used, and the patient is tested for sensitivity on the preceding day. The examination is done under local anesthesia supplemented with trichloroethylene, the patient being prepared with Pentobarbital and Pyribenzamine.

The needles are inserted into the aorta just below the level of the renal arteries, 5 c.c. of Urokon is injected, and a scout film is obtained, centered to include the lower aorta and iliac vessels. This serves as a second sensitivity test and also as a check on placement of the needles at the proper level. Providing the needles are properly placed and no intolerance to the procedure is exhibited, a second injection of 15 c.c. is made and an ordinary 14 × 17-inch Bucky film, centered

to include the lower aorta and upper 2 inches of the superficial femoral vessels, is taken. Thus, two films are available showing various degrees of filling of the aorta and iliac vessels, permitting assessment of the constancy of a particuar abnormality.

A third injection of 35 c.c. is made after the patient has been placed on a tunnel which holds two 14 × 36-inch cassettes, each containing two 14 × 17-inch films. The tunnel is made of plywood boards forming an oblong box open on one side. On each end is a track which supports a lead-lined tray that is wide enough to hold one of the two cassettes. One-half of the length of the tunnel is lead-covered to protect the top cassette in the tray. On the unprotected portion of the tunnel a Lysholm grid is placed. At the completion of the injection an x-ray exposure is made, affording visualization of the entire leg from the hip to the ankle The tray with the upper cassette is then pushed over to the unprotected portion of the tunnel with a short stick and a second exposure is made.

Two roentgenograms; 1 photograph.

B. J. PARNELL, M.D.
University of Texas, Dallas

Functional Venography with Injection into Superficial Veins. Thomas C. Moore. Surg., Gynec. & Obst. **100**: 721–729, June 1955.

Earlier studies by Shumacker, Moore, and Campbell (Surg., Gynec. & Obst. **98**: 257, 1954. Abst. in Radiology **64**: 138, 1955) on venography by injection of the contrast medium into the femoral and popliteal veins and into the superficial system appeared to indicate that the popliteal route would prove to be the most useful. Continuing investigation, however, suggests a role of greater importance for injection into the superficial system. Four cases are presented to illustrate the type of information which may be obtained by this procedure.

Although considerably more study will be necessary to establish the ultimate place of functional venography in the investigation of venous disorders of the lower extremity, the author believes that certain observations are in order. "When injection was made into the superficial system of normal patients or those with varicose veins or with a patent but recanalized deep trunk, the radiopaque medium filled the popliteal-femoral vein, passing proximally against gravity in the deep system rather than in the superficial system. The medium was cleared from the deep system by exercise. This was regarded as the normal mechanism for venous return from the superficial system of the dependent limb when the deep system was patent; even when damaged, without valves and recanalized. The superficial system in dependency seemed to serve principally as a collecting system for the superficial area for the central segmental passage of venous blood directly into the deep system rather than as a major channel in itself for venous return."

Because of these findings in repeated investigations, the proximal passage of the radiopaque medium against gravity in the superficial system combined with the failure of the deep system to opacify was regarded as exceedingly strong presumptive evidence of deep venous obstruction. Such evidence was encountered in 2 of the cases reported.

The demonstration of such deep venous alterations as recanalization and loss of valves was virtually as effective with injection into the superficial system as with injection directly into the popliteal vein. Superficial injection was also found to be more reliable and productive of less patient discomfort. It was more precise than the hit-and-miss probing necessary for percutaneous injection into the popliteal vein and less difficulty was experienced with the occasional complication of extravasation and the resulting transient severe pain accompanying it.

The capacity of a recanalized popliteal-femoral vein to function in the proximal transport of venous blood against gravity, demonstrated in previous studies by injection directly into the popliteal vein, was further emphasized by the findings in one of the cases reported. In this patient, Urokon, injected into the superficial system, passed proximally in the recanalized deep trunk in quiet dependency and cleared with exercise. This observation was regarded as additional evidence against ligation of the recanalized deep trunk in the postthrombotic state.

Thirty-two roentgenograms.

Phlebography of the Normal Leg. Torgny Greitz. Acta radiol. **44**: 1–20, July 1955.

A detailed investigation was made of the normal anatomy of the veins of the lower leg based upon phlebographic examination of 30 healthy subjects, ranging in age from twenty to forty-five years, and autopsy observations on 33 extremities from 18 cadavers. The phlebographic technic was that described earlier by the author (Acta radiol. **42**: 421, 1954. Abst. in Radiology **65**: 632, 1955).

Summarizing the autopsy findings, it may be stated that in the distal two-thirds of the lower leg there is generally one paired vein corresponding to each main artery. The posterior tibial and the peroneal veins are usually of the same size, often spindle-shaped, and larger than the anterior tibial vein. In the proximal third of the lower leg, where these veins open into the popliteal vein, the variations are numerous.

In all cases it was possible to fill the deep veins of the leg, *i.e.*, the deep veins of the lower leg, popliteal, femoral and external iliac veins. Non-filling of the femoral and iliac veins is not to be regarded as pathologic, as the contrast medium may be diluted, especially if varices are present. The profunda femoris vein, the concomitant veins of the popliteal and femoral veins, muscular veins, as well as the superficial and communicating veins, were inconstantly filled. They were, on the other hand, seen to such an extent that their filling cannot be considered pathologic. Muscular veins and communicating veins were filled in a retrograde direction.

[This is an excellent discussion of the normal findings on the basis of both anatomic dissection and roentgenologic studies.—J. P. C.]

Thirty-five roentgenograms; 1 photograph; 1 diagram.

J. P. CHAMPION, M.D.
Grand Rapids, Mich.

The Phlebographic Pathology of the Postphlebitic Limb. T. O. Murphy and D. A. Felder. Surgery **37**: 873–881, June 1955.

The authors present an analysis of the pathologic anatomy of the postphlebitic limb based on 83 phlebographic examinations. The findings are discussed with an aim toward a better understanding of the disease process and a more rational approach to surgical therapy. The importance of the communicating veins, the

sural veins, and the possible importance of venous bypasses in the thigh are stressed. The degree of incompetency seems to be related to the muscular and fascial support given to the veins.

Five roentgenograms; 1 table.

Venography and Surgery of the Postphlebitic Syndrome. George F. Johnson. Surg., Gynec. & Obst. **101:** 9–14, July 1955.

The author states that a satisfactory ascending venogram is necessary before any surgical procedure is attempted on an extremity with a previous history of thrombosis. This is particularly true in the surgical management of postphlebitic ulcers.

For this purpose, a 20-gauge needle which is attached to an intravenous drip is inserted into a small peripheral vein of the foot and an ankle tourniquet is placed lightly around the extremity. Thirty cubic centimeters of 35 per cent Diodrast is injected into a proximally occluded length of tubing with pressure as tolerated. Films are taken in rapid succession, as follows: (*a*) anteroposterior view of leg in 20 degree internal rotation; (*b*) a lateral view, with the tourniquet released; (*c*) a repeat anteroposterior view of the leg with the film shifted 2 to 3 inches cephalad; (*d*) after injection of 10 c.c. more Diodrast, a final anteroposterior view of the thigh, including the lower pelvis.

The sequence of events after deep venous thrombosis follows a pattern which it is important to understand in relation to the management of these cases. With the onset of deep obstruction, the blood flow is reversed toward the superficial veins. The communicating veins between the superficial and deep systems become incompetent, as does also the superficial system, so that there is incompetency of two of the three major venous systems of the lower extremity. The next event is recanalization of the deep venous system, and thus incompetency of the three major venous pathways is established. When recanalization occurs, postphlebetic ulcers develop.

Cases are presented showing this sequence of events and illustrations demonstrate the important veins which are the frequent causes of surgical failure.

Twenty-one roentgenograms.

THEODORE E. KEATS, M.D.
University of California, S. F.

THE DIGESTIVE SYSTEM

Surgical-Clinical Experiences with Roentgenology of the Pathological and Operated Esophagus. R. Nissen. Schweiz. med. Wchnschr. **85:** 669–675, July 9, 1955. (In German)

The author stresses the fact that x-ray examination is the most important basic method of diagnosing diseases of the esophagus. Early roentgen recognition of esophageal lesions is rather difficult, however, and in the absence of obstruction the rapid passage of the contrast medium prevents a systematic study of the mucosal relief.

The development of thoracic surgery in the last twenty years has led to unexpectedly good results, which could be even further improved if the diagnosis of esophageal cancer could be established at an earlier stage. In this connection, the author emphasizes the importance of esophagoscopy. This should be done routinely when the x-ray examination fails to explain the patient's complaint, with biopsy whenever any abnormality of the mucosal lining is observed. A warning is sounded against delaying for a control x-ray examination two or three months later, since too often mediastinal metastasis occurs during this waiting period.

Even esophagoscopy with biopsy is not infallible, and under certain circumstances small tumors can escape recognition. A tumor may be hidden by cardiospasm, develop in an old scar, or be easily overlooked within an esophageal diverticulum.

Hiatus hernias are discussed in detail. In paraesophageal hernias the possibility of incarceration with necrosis of the wall and even perforation must be considered if surgery is unduly delayed. Esophagitis and esophageal ulcer are found quite frequently and, in the opinion of the author, are probably the result of disturbance of the physiological sphincter mechanism at the cardia.

In recent years, displacement and indentation of the esophagus have gained in importance as diagnostic aids. They may be due to enlargement of the heart, mediastinal lymphadenopathy, as seen in bronchogenic tumors, or paraffinosis of the mediastinum following the injection of liquid paraffin to fill in extrapleural cavities.

Interesting systemic observations of postoperative conditions are reported, such as complete absence of the sphincter mechanism of the cardia after resection and the behavior of the stomach which has been operatively placed in the thorax and deprived of its vagal innervation. The function of the extrathoracic esophagus and stenosis at the anastomosis are also discussed. Each anastomosis between esophagus and stomach lacks a sphincter mechanism and therefore leads to reflux of gastric contents into the esophagus. If the anastomosis is high, the danger of aspiration into the bronchial passage exists, not only during food intake but especially during sleep, since the horizontal position increases the possibility of pharyngeal overflow.

In thoracic displacement of the stomach, coughing can easily produce regurgitation, since the stomach becomes atonic for weeks or months due to the necessary bilateral vagotomy. The latter also causes a pylorospasm for the same period of time. This association of gastric atony and pylorospasm permits an easier pressure exchange toward the mouth than toward the duodenum.

Resection of the muscular layers of the esophagus, as usually required in benign tumors, does not decrease the peristalsis. The denuded section bulges slightly but does not delay passage of the esophageal contents.

The present surgical achievements in carcinoma involving the upper and middle thirds of the esophagus are discouraging, and the author therefore suggests pre- and postoperative irradiation therapy. It is hoped that myocardial damage, frequently encountered following intensive irradiation of the mediastinum, can be prevented by the use of rotation therapy and that the surgical results can be improved by the combined methods.

Twenty-one roentgenograms; 4 photographs; 7 drawings.

HERBERT POLLACK, M.D.
Chicago, Ill.

Epidermoid Carcinoma Occurring in a Pharyngo-esophageal Diverticulum. Angelo Riberi, James Stanley Battersby, and Frank Vellios. Cancer **8:** 727–730, July-August 1955.

The authors were able to find in the literature only

10 reports of carcinoma occurring in pharyngoesophageal diverticula. They present the case of an 82-year-old white female who had had a mass in the neck, appearing after meals, for twenty years. A few years prior to entering the hospital, she had noticed that the mass was enlarging; more recently eating had become difficult and there was a considerable weight loss. With barium swallow, a typical Zenker's diverticulum was demonstrated. On excision, this showed an extensive area of mucosa in which there was a loss of orderly maturation of the squamous epithelium. Centrally within this region, neoplastic squamous epithelial cells invaded the underlying stroma. The intraepithelial carcinoma did not extend to the orifice of the diverticulum and thus was completely resected.

The chronicity of the diverticulum prior to the development of carcinoma in this case, and as reported in the literature, suggests that chronic inflammation and perhaps ulceration are contributing factors to the development of carcinoma. It is possible that invasive carcinoma is preceded by an intraepithelial neoplastic phase. Clinically, progressive dysphagia and unexplained weight loss in the presence of a diverticulum should arouse suspicion of carcinoma.

The only treatment is surgical excision of the diverticulum.

Two roentgenograms; 2 photomicrographs; 1 photograph.

JOHN W. WILSON, M.D.
University of Texas, Dallas

Early Roentgen Evaluation of Gastrointestinal Bleeding. Albert M. Kohn, Gene W. Sengpiel, and Joseph F. Wepfer. Wisconsin M. J. **54:** 331–334, July 1955.

Early roentgen examination of the upper gastrointestinal tract was found to provide an objective clinical diagnosis of the cause of gastrointestinal bleeding in 72.4 per cent of a consecutive series of 123 patients who underwent this examination. Sixteen of these patients had bleeding severe enough to cause shock, and in this group a positive diagnosis was made in all but 1 instance. The most common finding was duodenal ulcer, accounting for 66 cases; gastric ulcer was found in 19 cases and carcinoma in 3. There were 2 postbulbar and 2 stomal ulcers, and 1 patient had esophageal varices. In no case was gastritis considered to be the cause of bleeding, although swollen rugae with hypersecretion were noted in 9 patients. Surgery was performed in 6 cases, in each instance confirming the roentgen diagnosis.

Early examination was not felt by the authors to entail appreciable risk to the patient. Of the 123 patients, 89 were examined within ninety-six hours of admission. In only 3 was there any question of recurrence of hemorrhage immediately following the examination. In 1 case shock ensued and grossly bloody stools were passed, but the episode was controlled. In examining the patients in this series, palpation of the abdomen was done only when it was felt by the examiner to be necessary.

Three tables.

RICHARD G. LESTER, M.D.
University of Minnesota

Rupture of the Stomach in the Newborn Infant with Survival. Lawrence S. Mann, Irwin A. Kallen, August Tomusk, and Franklin P. Friedman. Surgery **37:** 969–972, June 1955.

A case of rupture of the stomach in a newborn male infant, secondary to a congenital defect in the musculature, is presented. At birth the child appeared in good health, with no abnormalities. At about forty-four hours, he refused to nurse and the abdomen became firm and distended. Three hours later the abdomen was still distended, tympanitic, and non-tender. Rectal examination with the little finger disclosed no obstruction; there was exceedingly free mobility of the colon, giving the impression that it was suspended in space. Roentgenograms in the upright and recumbent positions revealed pneumoperitoneum. The liver and spleen were pushed down, and free air was present under the diaphragm. There was no gas bubble in the stomach, but gas was seen in the large and small bowel.

A diagnosis of rupture of the stomach was made, and immediate surgery advised. Ten hours following the onset of distention, the abdomen was opened through a right paramedian incision. As the peritoneum was opened, air escaped under pressure, making a noise similar to that of air escaping from a tire. There was bile-stained fluid in the abdomen. The entire greater curvature of the stomach (about 2.5 inches in length) was ruptured. There was no evidence of peptic ulceration nor any bleeding from the walls of the ruptured portion. After closure of the rupture, thorough exploration was carried out but no other perforations or congenital anomalies were found. As much of the fluid as possible was removed by suction from the peritoneal cavity. Convalescence was uneventful.

The authors emphasize the importance of early diagnosis of a perforated viscus in a newborn infant. They believe that sufficient information can be obtained from x-ray studies without the use of barium or Lipiodol, and that these agents in the peritoneal cavity add to the peritonitis and possibly impair healing of neonatal tissue.

Two roentgenograms.

Roentgenological Findings in Gastric and Duodenal Ulcers in Children. Franz J. Lust. Am. J. Digest. Dis. **22:** 189–194, July 1955.

The author examines the upper gastrointestinal tract in children by a new method, which emphasizes spot-film roentgenography over fluoroscopy. He uses a shielded screen (Belloscope) in normal light so that his patients are not frightened by the darkness of the fluoroscopic room. The procedure was described in a paper in the American Journal of Gastroenterology, June 1955 (Abst. in Radiology **66:** 627, 1956).

The roentgenologic signs of ulcers in children are the same as those seen in acute ulcers in adults. Niches were discovered in the stomach, usually on the lesser curvature, principally in its distal half. In the duodenum, also, niches were found, and in some instances the duodenal bulb was deformed. In several cases the niche was in the second portion of the duodenum. Perforation is of frequent occurrence.

The author attaches considerable importance to the functional aspect of the examination. Gastric hypersecretion can be recognized, without the use of a stomach tube, on films of the upright patient, as a layer of relatively non-opaque gastric contents above the barium. Six-hour retention films also are useful in providing information regarding delayed gastric emptying.

[This paper would be improved by better correlation of the material, clinical and pathological. It is unfortunate, also, that the author ignored Girdany's report (Pediatrics **12:** 56, 1953. Abst. in Radiology **62:**

619, 1954), though it is possible that this appeared after the article was written.—A. S. T.]

Eleven roentgenograms.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Jaundice Due to Hypertrophic Pyloric Stenosis. James W. Martin and B. J. Siebenthal. J. Pediat. **47:** 95–99, July 1955.

Two cases are described in which jaundice is believed to have been due to pressure against the common bile duct by a pyloric mass. Both patients presented the typical clinical picture of hypertrophic pyloric stenosis. The first, a seven-week-old male, had been jaundiced since the second day of life. Surgery revealed a pyloric tumor angulated posteriorly and anchored around the lateral edge of the gastrohepatic ligament. It appeared to be actually incarcerated in the region of the foramen of Winslow. The gallbladder and common duct were not dilated. Following a conventional Ramstedt operation the jaundice rapidly disappeared.

The second infant, a five-week-old male, had been slightly icteric for about a week. He had experienced persistent forceful vomiting for two weeks and was quite dehydrated. The pyloric mass in this case, also, appeared to be angulated around the lateral edge of the gastrohepatic ligament, producing pressure on the common duct just above the pancreas, though again the gallbladder and extrahepatic biliary ducts appeared to be of normal size. Postoperatively, the jaundice disappeared promptly.

The authors believe that in these cases the unusual angulation of the pyloric tumors was responsible for extrinsic pressure on the common bile duct with resultant jaundice.

Two roentgenograms; 1 drawing.

H. G. PETERSON, JR., M.D.
New Britain, Conn.

Co-existent Volvulus of the Splenic Flexure and Cecum. Millington O. Young. Surgery **37:** 983–990, June 1955.

The case is presented of a 19-year-old male in whom a chronic volvulus of the splenic flexure of the colon causing partial obstruction was thought to have been the precipitating factor responsible for a volvulus of the cecum. Subsequent to detorsion of the cecum and roentgen studies of the colon, resection of the splenic flexure was performed, with relief of symptoms. This is believed to be the third recorded case of volvulus of the splenic flexure of the colon and the first instance in which this condition was associated with volvulus of the cecum. Roentgenograms are reproduced.

Intussusception in the Newborn Infant, with Spontaneous Expulsion of the Intussusceptum; A Case Report and Review of the Literature. Morton H. Rachelson, James P. Jernigan, and Wilbur F. Jackson. J. Pediat. **47:** 87–94, July 1955.

Intussusception, which is not uncommon in males between six and eighteen months of age, is extremely rare in the newborn. The authors' case, in a newborn female, is the twenty-ninth to be reported and is the first recorded instance of the passage of an intussusceptum per anus during the neonatal period. Following passage of a gangrenous segment of small bowel at thirty hours of age, the abdomen became distended and signs of intestinal obstruction appeared. A Lipiodol enema revealed an intussuscepting mass in the mid-transverse colon and brought about its reduction to the vicinity of the ileocecal junction, where complete obstruction was encountered. At operation it was found that a segment of ileum was missing, producing a V-shaped defect in the mesentery, with the ends of the bowel on either side sealed off. An end-to-end anastomosis was performed, and the infant recovered.

It is felt that intussusception occurred in this infant on the first day of life, since gas could be demonstrated through the colon on a plain film of the abdomen. The ends of the ileum at the defect became sealed off in the interval between the passage of the intussusceptum at thirty hours of age and the time of operation at fifty-six hours. Peritoneal spillage was apparently prevented because the intussusception was both ileo-ileal and ileocolic.

Two roentgenograms; 1 photograph; 1 drawing; 2 tables.

H. G. PETERSON, JR., M.D.
New Britain, Conn.

Barium Enema Reduction of Intussusception in Infancy. H. G. Hiller. M. J. Australia **2:** 157, July 30, 1955.

The author reports the results of an eighteen months clinical trial of barium enema reduction of intussusception in infants at the Royal Children's Hospital in Melbourne. In 24 of 41 patients the intussusception was reduced, with subsequent recurrence in 2. In the unsuccessful cases operative reduction almost always proved difficult. The technic is described, and it is concluded (1) that the advantage of a barium enema over a plain water enema lies in visualization of the actual reduction; (2) that the enema method, when successful, obviates anesthetic risk and postoperative complications, and the period of hospitalization is greatly shortened. On the other hand, failure of reduction does not entail a long delay before operation nor does it interfere with the surgical procedure.

The Demonstration and Pathology of Meckel's Diverticulum, with Report of a Case. L. Campbell Tainsh and Geoffrey Medhurst. Brit. J. Radiol. **28:** 351–354, July 1955.

This is the report of a preoperatively diagnosed Meckel's diverticulum which was demonstrated on a four-hour film after a barium meal.

The principal importance of Meckel's diverticulum lies in its liability to complications. These are reviewed along with comments on previously recorded cases. Acute inflammation, secondary intestinal obstruction, intussusception, hemorrhage, tuberculosis, involvement in regional ileitis, and foreign-body perforations are all discussed.

The roentgenologic diagnosis of a Meckel's diverticulum is unusual. Most have been demonstrated following a barium meal, but they may be shown by barium enema, especially in children.

Two roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Gallstone Obturation. Clinical and Roentgenographic Considerations. Leo S. Figiel, Steven J. Figiel, Fred K. Wietersen, and Edward J. Dranginis. Am. J. Roentgenol. **74:** 22–38, July 1955.

The authors present 17 cases of intestinal obturation

by gallstones and discuss the clinical and roentgenologic aspects of the condition.

Clinical manifestations are variable and frequently bizarre. Prior to extrusion of the calculus into the gastrointestinal tract, the signs and symptoms are usually those of an acute, possibly gangrenous, cholecystitis. With erosion of the gallbladder wall by the stone and discharge of the gallbladder contents into the intestine, symptoms are frequently relieved as a result of decompression of the acutely inflamed gallbladder. Subsequent manifestations depend upon the size of the calculus and the part of the gastrointestinal tract in which it lodges.

In 10 of the authors' cases, a diagnosis of gallstone obturation could be made from a study of survey films. A correct diagnosis was made in 3 other cases following ingestion of a barium meal. Thus, 80 per cent of the cases in their series could be diagnosed roentgenologically.

The roentgen criteria for the diagnosis of gallstone obturation are classified as follows:

(A) Gallstone obturation with roentgen evidence of ileus.
  1. Demonstration of biliary air
  2. Ileus
  3. Visualization of calculus
    (*a*) Opaque—aberrantly located biliary calculus
    (*b*) Non-opaque—accidental or purposeful ingestion of barium
  4. Change in position of calculus
    (*a*) From right upper quadrant—disappearance of calculus from right upper quadrant as evidenced from study of earlier films
    (*b*) Within the abdominal cavity on progress studies—after development of ileus

(B) Gallstone obturation without reliable roentgen evidence of ileus
  1. Demonstration of biliary air
  2. Visualization of calculus
    (*a*) Opaque
      (1) Transverse or horizontal orientation of the long axis of an ovoid calculus medially located in the upper abdomen should suggest obturation of the duodenal bulb
      (2) Aberrantly situated biliary calculus
      (3) Change in position of calculus on progress studies
    (*b*) Non-opaque—by means of contrast medium

Thirty-two roentgenograms; 1 photograph.

G. J. WOOLHANDLER, M.D.
Shreveport, La.

Cholelithiasis Simulating Pyloric Neoplasm. Donald Young. Brit. J. Surg. **43:** 105, July 1955.

A 72-year-old man with a four-week history of epigastric discomfort and an abdominal mass was found, on roentgen examination, to have a persistent deformity at the pylorus, which filled with difficulty. The appearance suggested infiltration of the pyloric antrum, probably neoplastic.

Operation revealed an inflamed gallbladder adherent to the anterior duodenal or pyloric wall, with penetration of the muscular wall but not of the mucous membrane. When the gallbladder was separated from the anterior wall of the duodenum, a fountain of small gallstones sprayed up from the stomach opening. This was explained by the fact that the mucous membrane had been separated from the wall for 3/4 in. and this space had been packed with small faceted calculi.

Two roentgenograms; 1 diagram.

JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

Rokitansky-Aschoff Sinuses as Related to Chronic Cholecystitis. Leonard K. Stalker, Baxter Davies, and T. Paul Guest. Arch. Surg. **71:** 124–127, July 1955.

The authors discuss the nature of Rokitansky-Aschoff sinuses of the gallbladder and call attention to the rarity of their roentgen diagnosis. Their demonstration justifies a diagnosis of cholecystitis and is an indication for surgery even in the absence of stones or other specific disease.

A case is reported in which the sinuses were shown roentgenologically and a diagnosis of chronic cholecystitis was made at operation. No stones were discovered.

Failure to demonstrate Rokitansky-Aschoff sinuses may be attributable to the small size of their orifices, failure of concentration of the medium, inspissation of bile, or cellular deposits. The radiographic picture has been described as showing round-bottom outpouchings from the mucosa into a thickened gallbladder wall. There may be poor contraction following the fatty meal, due to a stricture of the proximal portion of the gallbladder perhaps resulting from macroscopic sinuses containing bile pigment.

One roentgenogram; 1 photomicrograph.

SUE L. NICKEY, M.D.
University of Texas, Dallas

Emphysematous Cholecystitis. Report of a Case. Aksel Strömme. Acta radiol. **44:** 39–43, July 1955.

Emphysematous cholecystitis is an inflammatory process caused by gas-forming microbes characteristically producing gas in the gallbladder lumen, and usually in the wall and pericholecystic tissue as well. It is relatively rare and is most frequently seen in males, with diabetes and biliary calculi as predisposing factors. The exact route of the invading organisms is not known. Clinically the onset is like that of any case of acute cholecystitis with air becoming visible after approximately twenty-four hours. By forty-eight hours the gallbladder is distended with gas and can be seen on a scout film of the abdomen. Gradually the wall is involved, with the gas forming a ring of radiolucency around the gallbladder. Air then spreads to the pericholecystic tissues.

The most important consideration in differential diagnosis is biliary fistula, either spontaneous, following perforation by a calculus, or postsurgical. In fistulas, the wall and pericholic tissues are not involved, and the gas within the lumen is homogeneous and varies in amount from day to day.

If untreated, emphysematous cholecystitis may resolve spontaneously or may result in gallbladder rupture with peritonitis or abscess formation. The author favors conservative treatment with antibiotics rather than surgery.

A case in a twenty-seven-year-old male, with favor-

able outcome following conservative treatment, is reported.

Two roentgenograms.

J. A. GUNN, M.D.
Grand Rapids, Mich.

Traumatic Cholecystocutaneous Fistula. Orville F. Grimes and Howard L. Steinbach. Arch. Surg. **71**: 68–70, July 1955.

An unusual case of traumatic rupture of the gallbladder which resulted in a cholecystocutaneous fistula is presented. Localized peritonitis had caused sufficient necrosis of the abdominal wall to allow a liberated gallstone to work its way into the deeper musculofascial layers and it became encysted within these tissues. By injection of an opaque medium into the fistulous tract, its communication with the gallbladder was demonstrated. Also shown were the stone in the abdominal wall, stones in the gallbladder, the cystic and common ducts (normal caliber), and a portion of the duodenum.

Two roentgenograms; 3 sketches.

ROBERT B. CONNOR, M.D.
University of Texas, Dallas

The Use of the Fat-Rich Meal in Cholecystography. Lester R. Whitaker. Surg., Gynec. & Obst. **100**: 473–482, April 1955.

The author reviews the principle of the fatty meal in cholecystography and its application to diagnosis. It has been previously shown that in almost all cases the gallbladder completes its emptying and begins to refill after three or four hours. Consequently, if the first dose of radiopaque substance is given four hours after a fat-rich meal, there will be a better chance of its concentration with the bile in the gallbladder as it refills. If, then, another dose is given four to six hours later the chance of getting a dense shadow is improved. This is the basis of the author's "double-oral method" previously described (see Am. J. Roentgenol. **35**: 200, 1936. Abst. in Radiology **27**: 515, 1936).

The demonstration of the cystic and common ducts by the newer and denser substances such as Telepaque is dependent upon the stimulus of the fat-rich meal. If Cholografin is used intravenously, for demonstration of the gallbladder, it should be given about four hours after a fat-rich meal, when the gallbladder is presumably refilling and its bile is beginning to concentrate. If the object is to exhibit the common duct, it is probably better to have the gallbladder full of concentrated bile when the Cholografin is injected.

J. O. PERRITT, M.D.
University of Pennsylvania

Cholecystography in Patients with Vagotomy. A. Frank. Radiol. clin. **24**: 211–217, July 1955. (In German)

The purpose of the study reported here was to show how oral and intravenous cholecystography fare in patients who have had vagotomies but have no evidence of gallbladder disease on clinical examination. Eight patients in whom vagotomy had been done four to five years previously for duodenal ulcer were examined. Six of these patients had gallbladder shadows of poor density; in the other two the density was normal. Contraction after a fatty meal was good in all cases.

Poor concentration of the medium in these cases must not be taken as evidence of cholecystitis, but rather of interference with the innervation (hypotonia) of the sphincter of Oddi, so that the storage of concentrated bile (and medium) in the gallbladder is hampered. Slow emptying of the stomach probably plays a role as well, the repeated presence of its contents in the duodenum acting as a constant stimulus to gallbladder contraction, so that the concentration of the contrast substance within the latter organ remains inadequate.

Since the motility of the stomach is considerably impaired after vagotomy, cholecystography in these patients should always be done by intravenous injection rather than the oral method.

Three roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Intravenous Cholangiography. Gonzalo Esguerra-Gómez and Alfonso Castro-Riaño. Am. J. Surg. **90**: 4–11, July 1955.

Since it is not possible to demonstrate the biliary ducts by cholecystography or oral cholangiography when the gallbladder fails to visualize or in the cholecystectomized patient, intravenous cholangiography with Cholografin is recommended under these circumstances. Cholografin reaches the liver by way of the blood stream and is concentrated in the biliary ducts before reaching the gallbladder. The ducts therefore become visible even though the cystic duct is obstructed or the gallbladder has been removed or is atrophic or filled with stones. Visibility of the gallbladder itself with Cholografin is not dependent upon the state of its walls; it is sufficient that the organ be permeable for it to be demonstrated.

The generally accepted contraindications to intravenous cholangiography are serious disturbances of hepatic function, Basedow's disease, and hypersensitivity to iodine. The first of these the authors question, inasmuch as the percentage of the medium eliminated through the urinary tract increases with the degree of hepatic insufficiency and since some patients with non-obstructive jaundice have tolerated the iodized substance well.

Sixty-three patients were examined by the intravenous injection of Cholografin without unfavorable reaction. In 85.7 per cent an exact diagnosis of the state of the bile ducts was achieved. The gallbladder was visualized in 45.4 per cent of the patients in whom it was functionally non-demonstrable by cholecystography.

It is concluded that intravenous cholangiography is of great value not only because it affords knowledge of the biliary ducts before cholecystectomy but also because of the information furnished in cholecystectomized individuals. At the present time the only means of roentgen demonstration of odditis and intraductal stones in cholecystectomized patients is intravenous cholangiography.

Twenty-three roentgenograms.

BARBARA THOMPSON, M.D.
Indiana University

Simple Polyethylene Catheter for Operative Cholangiography. Louis H. Block and Theodore L. Orloff. J.A.M.A. **158**: 920–921, July 16, 1955.

Operative cholangiography *via* the cystic duct, as an aid in determining whether or not to open the common bile duct, is advocated by the authors. They prefer

it to direct puncture of the common duct because of the bile leakage frequently associated with the latter procedure. They also prefer the use of a catheter to T-tube injections, which may partially obscure and distort the common duct. Their polyethylene catheter, with a cuff just behind the tip, avoids technical difficulties incident to the procedure as usually performed.

A segment of polyethylene tubing 2 to 3 feet long (Clay-Adams PE50 or PE60; outside diameter 0.965 and 1.22 mm.) is used. The end of the tubing is threaded over a straight metallic stilet, the polyethylene is heat-softened, and a 2 to 3 mm. segment telescoped to form the cuff or ridge while the stilet preserves the integrity of the lumen. After cooling, the stilet is removed and the catheter "cold sterilized."

At surgery, the cystic duct is ligated at its junction with the gallbladder, and a second ligature is looped around the cystic duct closer to the common duct. The cystic duct is next partially opened between the ligatures and the bulbous catheter tip threaded toward the common duct past the second ligature, which is then tied down snugly but not so as to compress the catheter lumen. The catheter is withdrawn until the ridge is halted at the ligature. Filling of the catheter with saline before insertion prevents air bubbles. After removal of packs, and all radiopaque objects, cholangiography with 35 per cent iodopyracet (Diodrast) is carried out. Films are available by the time the cholecystectomy is completed and the findings are considered in deciding upon choledochotomy.

Three roentgenograms.

B. JAY HILL, M.D.
University of Michigan

RETROPERITONEAL TUMORS

Retroperitoneal Pneumography in the Diagnosis of Retroperitoneal Lymphomatous Neoplasms. Ralph M. Myerson and George T. Wohl. Am. J. Med. **19**: 155–158, July 1955.

The authors have found that retroperitoneal pneumography is a valuable adjunct in the diagnosis and demonstration of retroperitoneal lymphomatous neoplasms. They have studied 20 cases in this manner, 4 of which are reported. The usual technic for introducing the gas is modified by the use of a polyethylene catheter.

Retroperitoneal pneumography is believed to be well suited for the demonstration of mid-line retroperitoneal neoplastic masses. Recent experience with its use in patients with metastatic nodes from testicular tumors would seem to indicate that it will not demonstrate satisfactorily lesions less than 4 cm. in diameter.

Five roentgenograms.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

THE DIAPHRAGM

Roentgen Kymography of the Diaphragm. Bernard S. Epstein. Am. J. Roentgenol. **74**: 70–85, July 1955.

Kymographic study of the diaphragm in normal and in numerous pathological conditions was conducted. Examination was made in postero-anterior, lateral, and, in some cases, in oblique positions. The postero-anterior roentgen kymograms depicted the diaphragmatic excursions as inverted V-shaped waves, the ascending leg of the V corresponding to the expiratory phase and the downward leg to the inspiratory effort.

Normally, the height of the recorded waves was from 1.5 cm. to 6.0 cm., the average being between 2.5 and 4.0 cm. The angle of rise and fall with breathing was usually symmetric. The apex of the wave was generally sharp. Occasionally there was notching of the ascending and descending limb of the wave and blunting of the apex. The lateral and middle third of the left diaphragm sometimes had a higher excursion than the right diaphragm. Lateral film study indicated that the movement of the diaphragm was greater posteriorly than anteriorly.

The rib movements with respiration were inverse to those of the diaphragm. The ribs rise while the diaphragm descends with inspiration. Movement of the clavicle and even of the thoracic spine could be studied.

Scalloped diaphragm is a developmental anomaly apparently of no pathologic significance. The domes of large scallops showed diminished excursion, but their motion was in phase with the remainder of the diaphragm.

In *eventration of the diaphragm* kymography disclosed a lag in onset of the respiratory waves on the involved side in relation to the movement of the right side, but no paradoxical movement. The wave forms were diminished, blunted, and irregular.

In *emphysema*, wave forms and timing of the movements of diaphragm and ribs were normal, but the amplitude was somewhat decreased.

The wave forms varied in the presence of *pneumothorax*. In 3 cases of partial pneumothorax diaphragmatic motion was normal.

In cases of *pleural effusion*, the wave appeared along the upper margin of the fluid. It was unchanged with moderate collections but was damped out by larger effusions. A carbonated drink was useful for visualizing the movements of the diaphragm through the stomach bubble.

No change in movement of the diaphragm was noted in the presence of *pulmonary neoplasms*, with the exception of lower lobe growths with associated consolidation and pleural effusion, where the wave was diminished. With mediastinal extension, there was more likely to be abnormal diaphragmatic movement. This was interpreted as due to phrenic nerve involvement.

In 3 cases of *right subphrenic abscess* the roentgen kymograms showed complete absence of mobility of the diaphragm. In the remaining 9 there was moderate restriction of motion, together with variable slight blunting of the apex of the waves and a slight lag of the onset of the expiratory wave. In the cases of *left subphrenic abscess* similar changes were noted except for the fact that complete restriction of motion of the left diaphragm was not observed.

After gallbladder and stomach surgery, the diaphragm was temporarily elevated and showed reduced excursion. This was believed to be secondary to surgical manipulation.

In 2 cases of *phrenic crush*, mobility of the diaphragm was restricted; in a third it was not.

Disturbance of diaphragm movement was recorded in 8 out of 25 proved cases of *metastatic cancer of the liver*. The wave forms were similar to those seen with subphrenic collections, with diminished amplitude, blunted tops, and a lag in onset of the expiratory wave.

Restriction of movement was noticed in 4 of 10 patients with *splenomegaly* and was not related to spleen size.

One patient with a massive *kidney tumor* on the right

showed marked restriction of diaphragmatic movement.

No change of movement worthy of note was found with *pneumonia, pneumoperitoneum, hepatodiaphragmatic interposition of the colon,* and in 1 case of *right-sided hiatal hernia.*

Thirty-two roentgenograms (19 kymograms); 1 table.

WILLIAM SNOW, M.D.
Shreveport, La.

Partial Eventration of the Right Diaphragm (Congenital Diaphragmatic Herniation of the Liver). Alfred Vogl and Allan Small. Ann. Int. Med. **43:** 61–82, July 1955.

Six cases of partial eventration of the right diaphragm are described by the authors. Five were of the more common type, involving the anteromedial part of the diaphragm, while in 1 patient there was eventration of the central portion. The benign nature of this condition is stressed, and the importance of not mistaking it for a more serious lesion is brought out. Rarely, symptoms of intermittent incarceration of the liver may be observed.

In most cases the diagnosis is made in the course of routine roentgen examination. A semicircular or semiovoid mass of soft-tissue density is seen in the right lower lung field, arising from the diaphragm with a broad base. On fluoroscopic examination absence of movement of the involved portion of the diaphragm or paradoxical movement is seen. While this combination of findings is usually sufficient for diagnosis, the authors suggest the use of artificial pneumoperitoneum in those cases where unequivocal confirmation is needed. When this method is used, the diaphragm stands out as a thick line, with the area of eventration presenting as a thinner semicircular pouch projecting upward.

Pneumoperitoneum also demonstrates a bulge in the right lobe of the liver, with a dome-shaped convexity filling the area below the eventration. This represents the so-called superior accessory lobe of the liver, a constant finding with this deformity. The authors believe that the eventration is primary and is the result of a congenital aplasia or hypoplasia of the musculature of a portion of the right diaphragm and that the underlying portion of the liver prolapses into the diaphragmatic pouch as it develops and molds itself into the abnormal space, thus forming an intrathoracic but subdiaphragmatic accessory lobe.

The name "congenital diaphragmatic herniation of the liver" is offered as the clearest designation of the entire anomaly.

Twenty-two roentgenograms; 3 drawings; 1 photograph.

RICHARD G. LESTER, M.D.
University of Minnesota

THE MUSCULOSKELETAL SYSTEM

Osteopetrosis in Adults. C. L. Hinkel and D. D. Beiler. Am. J. Roentgenol. **74:** 46–64, July 1955.

The authors review the clinical and roentgen findings of osteopetrosis in adults and present 5 cases of their own, showing characteristic bony changes. The disease in adults is believed to represent a less "malignant" form than is seen in infancy. Hematologic and neurologic findings are minimal or absent, and the long bone clubbing, medullary narrowing, and foramen encroachment seen frequently in the infantile form, are not prominent. The disease may be entirely asymptomatic.

The basic roentgenographic change in osteopetrosis is a bilateral symmetrical increase in density of the bone with a loss of the normal trabecular pattern. From a strictly roentgenologic standpoint, there is no clear distinction between the benign and malignant types. Diagnosis can be made in most cases on the basis of the following roentgen and clinical characteristics:

1. The disease is generalized, although some bones may be spared.
2. There is usually involvement of the posterior clinoids, spine, pelvis, proximal humeri and both ends of the femurs.
3. There is a striking symmetry of the lesions.
4. The "bone within a bone" appearance is often seen in the pelvis, ribs, epiphyses, carpals, and tarsals.
5. There are usually transverse and longitudinal striations in the metaphyses.
6. The vertebrae may present a "sandwich" appearance.
7. The disease probably begins in early childhood.
8. It may be found in other members of the family especially in siblings.
9. Anemia is moderate or absent; seldom severe.
10. The serum alkaline and acid phosphatase, blood calcium, and phosphorus are essentially normal.
11. Enlargement of the liver and the spleen is uncommon.
12. There is a predilection to fracture.
13. There may be periodic or permanent remissions.
14. The course is clinically benign.

The following conditions may also be associated with increased density of bone and may simulate osteopetrosis to a variable degree: myelosclerosis, fluorosis, lymphoblastoma (especially Hodgkin's disease and leukemia), metastatic osteoblastic carcinoma, Paget's disease, lead, bismuth, and phosphorus poisoning, infectious osteitis, osteopathia striata, and Engelmann's disease.

Such information as is available on the pathology of adult osteopetrosis has been obtained by biopsy. The bones are heavy, thick, dense, hard, and brittle. The medullary cavity is reduced in size or is practically absent. The increase in density results from faulty resorption of endosteal and periosteal bone and matrix. Myelogenous cells and unresorbed matrix are found in the bones as late as the seventh decade. Osteopetrotic bones are increased in weight, fragility, and mineral ash content.

Several theories of the pathogenesis of the disease have been offered. These are as follows: (1) primary disease of the osseous system, with the laying down of abnormal matrix which is resistant to normal resorption; (2) primary inflammatory disease; (3) primary endocrine disturbance; (4) faulty differentiation of the primitive common forerunner of osteogenic and hematogenic tissue.

There is considerable difference in opinion as to the exact form of onset and course of osteopetrosis. The authors feel, after studying the reported cases, that all indications are that the process usually begins very early in life, but does not affect all bones equally or simultaneously except in fulminating, clinically malignant cases. They believe that no one has ever described a normal skeleton in a patient who later developed this disease.

Eighteen roentgenograms; 1 photomicrograph; 4 drawings; 2 tables.

G. J. WOOLHANDLER, M.D.
Shreveport, La.

Radiological Bone Changes and Angiographic Findings in Leprosy, with Special Reference to the Pathogenesis of 'Atrophic' Conditions of the Digits. D. E. Paterson. J. Fac. Radiologists **7**: 35–56, July 1955.

The observation that the "neurotrophic" changes in bone associated with leprosy are sometimes duplicated by mycetoma, psoriasis, and chronic infection led the author to an investigation of the radiographic and angiographic findings associated with leprous bone lesions. The ends of the phalanges and metatarsals are the main sites of involvement, and the study is limited to these areas.

There are 2 fundamental types of bone change in leprosy: (1) bony destruction in the medulla, apparently due to the action of *M. leprae* on the reticuloendothelial system; (2) bony absorption in the superficial layers of the cortex, apparently the result of soft-tissue infections which may follow upon the anesthesia caused by leprous nerve lesions. These changes are manifested by pseudocyst formation and subperiosteal or subarticular bone destruction, which may develop into a smooth cupping of the articular surface. The occurrence of trauma in anesthetic areas or infection leads to periostitis, osteitis, osteomyelitis, hematomata, subluxations, and Charcot joints. Following apparent healing of superficial infections, deep sepsis probably persists and tracks along the periosteum, quieting down with rest of the part.

Oftentimes, while the concentric absorption of the shaft is taking place, new trabeculae are laid down on the medullary side of the cortex, producing a relative increase in density of the narrowed tapering shafts. Osteoporosis is unusual in leprosy unless there are marked contractures.

Angiographic findings indicate that associated with areas of bone absorption there are usually defects in the vascular end loops. Delay in venous emptying and venous shunts may occur. The author suggests that changes in the digital arteries and end loops are due to the presence of non-specific infection, periostitis, hematoma, or soft-tissue devitalization. If the end loops and veins draining the medullary portion of bone are protected, new bone formation is able to continue, with an apparent increase in density.

Fifty-nine roentgenograms; 1 drawing; 3 tables.

DON E. MATTHIESEN, M.D.
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Cervical Air Myelography. A Review of 130 Cases. F. Murtagh, W. E. Chamberlain, M. Scott, and H. T. Wycis. Am. J. Roentgenol. **74**: 1–21, July 1955.

Negative contrast myelography with air and oxygen, although not as dramatic as examination with positive contrast agents, is a much safer method. The authors feel that it has definite usefulness as a diagnostic procedure, although not as a complete replacement for studies with opaque material. The medium is innocuous, has no prolonged irritative effects, and is completely absorbable.

Three methods were used in this study.

(A) Twenty-four patients were examined by injecting 5 to 10 c.c. of air after removal of a similar amount of fluid. The patient was examined in the upright position in front of a Potter-Bucky diaphragm. If he complained immediately of severe headache, it was assumed that all of the air had passed into the cranial cavity and that no block existed in the canal. If no headache was present, films were taken on the assumption that a block existed. In 17 of the 24 cases a complete or nearly complete block was demonstrated.

(B) Fifty-nine studies were made after replacing the 40 to 50 c.c. of spinal fluid with air. By careful manipulation of the patient, the air could be trapped in the cervical region. By this means, 47 examinations were completed satisfactorily.

(C) Fifty-nine studies were made by complete withdrawal of the spinal fluid and replacement with air; 48 of these studies were successful.

Only lateral views of the cervical spine were of value. Anteroposterior views were useless.

The following lesions were diagnosed: malformation of the cervical spine with cord compression (10 cases); injury to the cervical spine (4 cases, with complete block in 2 and no block in 2); herniated intervertebral disks or encroachment upon the cervical roots by protruding osteophytes (32 cases); space-occupying lesions of the cervical canal, including tumors, syringomyelia, and intramedullary hemorrhage (13 cases).

Atrophy of the cord was demonstrated in 14 cases, in all of which the cord measured less than 8 mm. in thickness.

The following are among the authors' conclusions:

In the presence of a complete block, the injection of a small quantity of air (5 c.c.) will clearly demonstrate the lower level of block.

Non-obstructive lesions can be visualized with larger quantities of air. This is of particular value in lesions at the medullospinal junction and foramen magnum area, where it is difficult to manipulate the viscid, radiopaque agents in the absence of a block.

Complete drainage of the cerebrospinal axis and replacement with air afford the clinician a complete objective evaluation of the brain and any portion of the spinal canal.

Twelve roentgenograms; 11 drawings; 4 photographs.

G. J. WOOLHANDLER, M.D.
Shreveport, La.

Myelographic Aspects of Spinal Arachnoiditis. G. Lombardi and A. Passerini. Radiol. med. (Milan) **41**: 654–662, July 1955. (In Italian)

"Primary" spinal arachnoiditis may be due to infectious diseases, trauma, irritating intraspinal injections (anesthetic, therapeutic, oily contrast substances), etc. Because of the clinical polymorphism of the syndrome, myelography is of major diagnostic significance in doubtful cases. This paper relates the findings in 25 patients in whom spinal arachnoiditis was the only pathological condition discovered during surgery (cases associated with angiomata and other tumors, vertebral fractures, herniated disks, and open trauma, as well as arachnoiditis "secondary" to other disease were excluded). The etiology was known in 11 of the cases: closed trauma in 3, syphilis in 3, tuberculosis, typhus, gonorrhea, ulcus molle, and intraspinal serotherapy in 1 case each. Lipiodol was the contrast material used.

Adhesions were distributed as follows: 5 in the cervical, 14 in the dorsal (11 in the lower tract), and 6 in the lumbar spine. Complete block was present in 17 of the 25 patients. Because surgery is useless or even harmful when the adhesions are too extensive, investigation above and below the block appears indicated.

Typical myelographic findings were obtained in 12 patients. In *partial block*, after a delay at the margin of the lesion, the contrast substance penetrated between

the adhesions, often demonstrating a narrowed, irregular, sinuous channel, extending sometimes over several vertebral bodies. The appearance is usually bizarre, but its constancy may be confirmed by reexamination. Cystic changes were found in only 1 case. In *complete block*, the oil is "retained" permanently (twenty-four-hour recheck) within saccular recesses formed by the adhesions. The peripheral location of these pouches as related to the cord, proved by oblique and lateral projections, is a diagnostic feature, as is the irregular outline of the arrested contrast material, which appears denser on subsequent examination (forty-eight to seventy-two hours).

Atypical myelographic findings include a transverse arrest line (which may be interpreted erroneously as due to herniated disk when corresponding to an intervertebral space) and a dome-shaped interruption of the contrast column, most often attributed to tumor.

Twenty-five roentgenograms; 2 drawings.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Diagnosis and Surgical Therapy of Chronic Midline Cervical Disk Protrusions. Eric T. Yuhl, Duke Hanna, Theodore Rasmussen, and Richard B. Richter. Neurology **5**: 494–509, July 1955.

The authors discuss the diagnosis and surgical therapy of chronic mid-line cervical disk protrusion on the basis of their experience with 32 patients seen at the University of Chicago Clinics. The cases were reviewed in respect to symptoms, common neurologic findings, examinations of the cerebrospinal fluid, plain radiographic examinations of the spine, myelography, findings at operation, and follow-up results.

Cervical disk herniation may be divided into three types: (1) lateral protrusion, (2) acute mid-line protrusion, and (3) chronic mid-line protrusion. Lateral protrusions, which comprise the largest of the three groups, produce the signs and symptoms of compression of one or more cervical nerve roots. Acute mid-line protrusions, the rarest of the three types, exhibit signs and symptoms similar to those of intraspinal neoplasm. This report deals solely with the third group, the chronic mid-line protrusions.

The radiographic studies of the cervical spine included stereoscopic films in the anteroposterior, lateral, and right and left oblique projections. In 20 of the 32 patients, the curvature of the cervical spine was altered. In 15, the alteration consisted of straightening of the normal cervical curve; in 5 there were varying degrees of reversal of the normal curvature. Twenty patients showed narrowing of several intervertebral disk spaces. The presence of posterior or posterolateral osteophytes on the vertebrae was the most constant radiologic finding and was observed in all but 1 of the series. Some degree of encroachment on the intervertebral foramina was present in all but 1 patient.

In 30 patients myelography revealed central filling defects opposite the cervical intervertebral disks at more than one level; in only 2 patients were single defects seen. The severity of the lesions demonstrated varied from minimal central protrusion of the intervertebral disk at one or two levels, without lateral extension, to nearly complete subarachnoid block. Occasionally the bony spurs predicted accurately the size of the filling defect, but more often the correlation was poor. Large filling defects were associated with minimal abnormality as shown on the plain roentgenograms; severe bony changes were often associated with much smaller filling defects.

In some instances, the filling defects were equally well visualized in both the anteroposterior and lateral projections. If the lateral gutters were shallow, the defect was more pronounced on the lateral films. If the lateral gutters were deep and well filled, the defect was often minimal or absent on the lateral projection and appeared mainly as a mid-line radiolucent area in the anteroposterior projection.

It seems probable that a significant proportion of patients that have been classified in the past under such diagnoses as primary lateral sclerosis, progressive spinal multiple sclerosis, chronic degeneration of the spinal cord due to arteriosclerosis, atypical amyotrophic lateral sclerosis, etc., may be suffering from a low-grade mechanical compression of the ventral aspect of the spinal cord due to mid-line cervical disk protrusion or ridges. Since the changes in the spinal cord produced by these lesions are often irreversible, early diagnosis and treatment are particularly important.

Twenty-three roentgenograms.

THEODORE E. KEATS, M.D.
University of California, S. F.

Transient Intervertebral Disk Calcification in Childhood. E. Kotscher. Radiol. clin. **24**: 197–201, July 1955. (In German)

The author reports a case of transient calcification in the nucleus pulposus of a cervical disk in a girl nine years of age, with no significant antecedent history other than the fact that she had taken ballet lessons. She complained of pain in the neck and considerable limitation of motion.

Most of these transient calcifications disappear within several weeks or months. Usually only a single cervical or thoracic disk is involved. The calcification may be preceded by a short febrile episode with leukocytosis, or may follow severe exertion. Some cases are asymptomatic.

While the calcification in adults is probably a degenerative process, being found in the lower regions of the spine, which are more concerned in weight-bearing, transitory calcification in children must have another explanation. Trauma and infection may play a role. It is noteworthy that in some of the reported cases a deformity has been demonstrated in one of the neighboring vertebral bodies. The author's patient showed such a deformity (wedging) in the body of the vertebra cranial to the calcified nucleus. Later, sclerosis of its end plate was demonstrated, suggesting the possibility of an aseptic necrosis.

That congenital factors may play a role is suggested by the occasional observation of associated malformations in other systems, such as persistent ductus arteriosus, deformed external auditory canal, etc.

Three roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Bony Masses Projecting into the Spinal Canal Opposite a Break in the Neural Arch of the Fifth Lumbar Vertebra. Lee A. Hadley. J. Bone & Joint Surg. **37-A**: 787–797, July 1955.

The author implies that many of the interarticular defects seen in the lamina of the fifth lumbar vertebra may be due to fracture. He sites a series of cases with roentgenograms showing callus-like bony masses pro-

jecting into the spinal canal. In most of these there was a break in continuity of the neural arch of the fifth lumbar vertebra on one or both sides. In 20 of a series of 29 cases of bony masses in the vertebral canal some degree of spondylolisthesis was observed. In 6 there was a unilateral break in the neural arch of the fifth lumbar vertebra. Seven of the patients gave a history of trauma sufficiently severe to have caused a fracture of the neural arch.

The author suggests that these bony masses may be the result of callus formation secondary to injury. Actually, the majority of the illustrations accompanying the paper show failure of fusion of the laminae, poorly formed laminae, and other signs of congenital anomalies at this level.

Twenty-five roentgenograms; 2 photographs.

ALFRED O. MILLER, M.D.
Louisville, Ky.

X-Ray Diagnosis in Backache by Use of Plain Roentgenograms. Lányi Arnošt. Acta radiol. & cancerol. bohemoslov. **8:** 193–200, September 1954. (In Czechoslovakian)

This article describes the diagnostic highlights of radiological importance in pathologic abnormalities and lesions of the spine, including (1) developmental changes (anatomical variations, malformations, abnormalities, and deformities); (2) degenerative bone changes (spondylosis deformans, deforming intervertebral arthrosis, osteochondrosis with vertebral dislocation or herniation of an intervertebral disk); (3) inflammatory or infectious changes (tuberculosis, osteomyelitis, etc.); (4) traumatic lesions (localized post-traumatic spondylosis, Kümmel-Verneuil disease, etc.); (5) neoplasms, both primary and secondary.

Eight roentgenograms. ERNST A. SCHMIDT, M.D.
Hilo, Hawaii

The Measurement of Tibiofibular Torsion. Howard Rosen and Herbert Sandick. J. Bone & Joint Surg. **37-A:** 847–855, July 1955.

Tibial torsion is assumed to be frequently associated with a number of congenital and acquired deformities of the foot and knee. In certain conditions, such as clubfoot, genu varum, and genu valgum, it appears to play an important role. Treatment requires an exact determination of the degree of axial torsion, but none of the current methods of measurement is entirely satisfactory. The authors have therefore devised a new roentgenographic technic. For those interested in this, the original article is recommended, as it is impossible to describe the method and manner of studying the films without aid of the original photographs and diagrams. The procedure is applicable to torsion ranging from −45° of medial to +75° of lateral torsion and can be used in both children and adults.

Five roentgenograms; 3 photographs; 2 drawings; 1 diagram. ALFRED O. MILLER, M.D.
Louisville, Ky.

Horseshoe-Shaped Baker's Cyst of the Knee: Report of a Case. Bruce M. Cameron and Frank O McGehee. J. Bone & Joint Surg. **37-A:** 863–865, July 1955.

The authors report a case of Baker's cyst of the knee joint with two pedicles. The patient was seen approximately three years after he had been struck in the back of the left knee with a heavy piece of iron. Shortly thereafter, a small tumor developed on the posterolateral side of the knee. Following the original injury, there had been intermittent generalized swelling, and as the swelling receded it seemed that the lateral tumor had grown a little larger.

Examination showed a large, fluctuant, fixed, moderately tender mass in the popliteal fossa. No synovial thickening or swelling was noted anteriorly, and the ligaments were normal. Roentgenograms of the knee revealed no abnormality of the bones or joint other than the soft-tissue mass in the popliteal fossa.

At operation, a large horseshoe-shaped cyst was exposed, which was attached to the knee joint cavity by two distinct pedicles. The first pedicle was attached laterally, under the tendon of the biceps femoris; the second, under the medial head of the gastrocnemius muscle. Recovery was uneventful.

Two roentgenograms; 1 photomicrograph; 1 photograph. ALFRED O. MILLER, M.D.
Louisville, Ky.

GYNECOLOGY AND OBSTETRICS

The Roentgenologic Diagnosis of Intrauterine Fetal Death. O. Wichtl. Fortschr. a. d. Geb. d. Röntgenstrahlen **83:** 86–95, July 1955. (In German)

The present study is based on the analysis of 48 cases of intrauterine fetal death (37 cephalic presentations, 7 breech, 3 transverse, 1 extrauterine, 4 acranii, 2 twin pregnancies), distributed as follows: 3 before the sixth lunar month, 1 in the sixth month, 10 in the seventh, 9 in the eighth, 8 in the ninth, and 17 in the tenth.

The best known and the most reliable of the skull signs of fetal death is Spalding-Horner's sign, *i.e.*, overlapping (overriding) of the bones of the calvarium, in the absence of engagement or actual labor. Because of the possibility of a false positive, especially in the case of a near-term fetus with a large head, overriding of 2 to 3 cm. is required for the diagnosis in the tenth lunar month. Skull changes were present in 30 of the author's series; 12 were in the tenth lunar month but, because of the stringent requirements for a "true" positive, the diagnosis was made in only 3 cases.

A stair-shaped deformity of the skull proved helpful in recognition of fetal death before the tenth month. A late sign, caused by maceration, is gross asymmetry and marked reduction in size of the skull.

Abnormal angulation of the spine, particularly if progressive on successive examinations, is positive evidence of intrauterine death. It is best seen when the film is exposed with the mother erect. It was present in 16 cases, and considered diagnostic in 6. Abnormal extension of the fetal spine (on roentgenograms taken with the mother in prone position) is of doubtful value, being a common finding in the living acranius. The cadaveric rigidity occasionally mentioned in the literature is at best a chance finding (not seen in this series). Collapse of the thorax may occur after early death and maceration.

Discrepancy between expected and actual size of the fetus is helpful when the date of conception can be accurately determined: it was present in 5 cases and considered suggestive in 2. Absence of growth on progress films is significant; repeat examinations were obtained in 7 of the author's patients and were diagnostic in 2. Contrary to widespread belief, changes of fetal position may occur after intrauterine death.

Summing up, the diagnosis of intrauterine death was obtained more frequently before the tenth lunar month. This is explained by strict adherence to the definition of the "true" Spalding-Horner sign. Even in retrospect, characteristic symptoms were absent from the roentgenograms in 19 cases, including the 4 acranii. The number of positive diagnoses could be increased by obtaining progress films in doubtful cases, and by adding a view with the mother in standing position.

Five roentgenograms; 4 tables.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

THE GENITOURINARY SYSTEM

Preliminary Clinical Evaluation of Hypaque in Excretory Urography. Robert M. Lowman, Harrison Shapiro, Albert Lin, Leonard Davis, Francis E. Korn, and Harry R. Newman. Surg., Gynec. & Obst. **101:** 1–8, July 1955.

Hypaque (sodium, 3,5-diacetamido-2,4,6-triiodobenzoate), a new urographic contrast medium, was tested in 300 patients. The medium was found to resemble Urokon in its pattern of excretion. It produced kidney visualization more rapidly than Diodrast, with sharper delineation of the urinary structures. Densities obtained with 50 per cent Hypaque simulated those obtained with other media of 70 per cent concentration. Approximately 85 per cent of the urograms completed following Hypaque injection were considered good or excellent in quality.

The drug is rapidly eliminated in unchanged form. When tested in experimental animals, it was extremely well tolerated in doses many times the amount of the probable clinical dose.

Few reactions were encountered. One or more of the following signs were noted in 8 patients of the total group studied: nausea, vomiting, dizziness, and transient flushing. A total of 15 patients showed reactions if minor vasomotor and psychogenic side-effects are included. No true allergic signs were noted. The virtual absence of vein cramp was noteworthy.

In the authors' hands, Hypaque has proved to be a satisfactory, efficient, and safe urographic contrast medium.

Nine roentgenograms; 4 tables.

THEODORE E. KEATS, M.D.
University of California, S. F.

Intravenous Urography. Improved Technique Using Dimenhydrinate (Dramamine) to Prevent Undesirable Side-Effects; Preliminary Report. David Robinson and Jerome M. Vaeth. Arch. Surg. **71:** 78–79, July 1955.

A preliminary study of the possible effectiveness of premedication with antihistaminics prior to intravenous urography is presented. Of 51 unselected patients receiving intravenous contrast material without premedication, approximately 20 per cent exhibited nausea, vomiting, and flushing, which are thought to be the central effect of iodine media on the emetic mechanism. In a second group of 51 unselected cases in which dimenhydrinate was administered intravenously five minutes prior to injection of the contrast material there was complete absence of these reactions. Further investigation is being conducted at this time.

ROBERT B. CONNOR, M.D.
University of Texas, Dallas.

Genitourinary Tract Screening as a Routine Procedure in Angiocardiography. John W. Lawlah, John B. Johnson, and Audrey I. Fairley. J.A.M.A. **158:** 921–922, July 16, 1955.

The amount and concentration of contrast material injected for angiocardiography are more than adequate for intravenous pyelography. The authors obtained films of the kidneys, ureters, and bladder five to fifteen minutes following angiocardiography, as a method of urinary tract screening, in 70 patients studied by that procedure. These patients had a variety of cardiorespiratory diseases both congenital and acquired, but in none was any genitourinary abnormality suspected.

In 10 per cent of this group "some type of urinary tract abnormality" was detected. "In several instances, the patient's health as a whole was affected by the urinary tract disorder." Two cases are specially cited: bilateral pelvic kidneys in a boy of fifteen and bilateral dilatation of the pelvis and ureter in a sixty-five-year-old man. Further studies in the latter case demonstrated a congenital bladder neck obstruction.

The authors recommend a follow-up film of the kidneys, ureters, and bladder as a routine screening procedure following angiocardiography.

Two roentgenograms.

B. JAY HILL, M.D.
University of Michigan

Cineradiography of the Urinary Tract. Howard G. Hanley. Brit. M. J. **2:** 22–23, July 2, 1955.

Use of an image amplifier and moving picture camera together enabled the author to carry out cineradiographic studies of the urinary tract. Only one kidney could be visualized at a time, since the maximum field is limited to 5 inches in diameter by the size of the image amplifier tube.

This article consists mainly of a discussion of the potentialities of the method but is illustrated by a series of 9 normal retrograde pyelograms.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Percutaneous Antegrade Pyelography and Hydronephrosis. Direct, Intrapelvic Injection of Urographic Contrast Material to Secure a Pyeloureterogram After Percutaneous Needle Puncture and Aspiration of Hydronephrosis. William C. Casey and Willard E. Goodwin. J. Urol. **74:** 164–173, July 1955.

Direct needle puncture of the kidney pelvis, with aspiration of urine and introduction of a contrast agent, is not difficult in large hydronephroses and is a useful diagnostic measure in selected cases. The authors believe the procedure should probably be reserved for cases of known or suspected hydronephrosis exceeding 20 c.c. in volume, in which diagnosis is incomplete or cannot be definitely made by conventional methods of pyelography. In any event, scout films and excretory and retrograde urograms should be done (or attempted) before undertaking "antegrade" pyelography.

After pelvic puncture, 15 c.c. of urine is aspirated and 10 c.c. of Neo-Iopax (50 or 75 per cent) or Urokon (70 per cent) is injected. If a large hydronephrosis is encountered, more contrast medium may be used. The authors emphasize the fact that the amount of medium injected should always be less than the quantity of urine aspirated. When, in their early experience, this rule was violated, some "cystoscopic-like" reactions oc-

curred. Increased intrapelvic pressure produced pyelovenous, pyelolymphatic, pyelotubular, and interstitial reflux, which in infected cases could lead to bacteremia. Delayed films at hourly intervals were used to show emptying and reabsorption of the pelvic contents. The occasional presence of medium in the perirenal space was found to be associated with transient local pain.

The authors believe that the total amount of contrast medium should not exceed 10 or 15 c.c. In 2 patients where over 40 c.c. were injected, chills, fever, and vomiting occurred. In another patient who was given multiple needle punctures of both kidneys on one day a temporary reflex ileus developed.

In a nine-month interval antegrade urography was attempted in 55 patients. In 7 it proved impossible to puncture the renal pelvis. In 4 others, resulting roentgenograms were of no help. These failures occurred in patients with small hydronephroses or nearly normal kidneys, on whom the procedure should not have been tried.

The authors describe 2 cases in which the procedure furnished diagnostic information which could have been obtained by no other method. One of these patients was a boy with very poor kidney function due to a longstanding obstruction as the result of a scar at the ureteropelvic junction; the other was a woman with hydronephrosis and hydroureter due to an obstruction 3 cm. above the vesical orifice, which prevented catheterization. In the latter case, a forty-five-minute film showed excretion by the opposite kidney. This visual evidence of reabsorption from the hydronephrotic kidney pelvis is considered to indicate either incomplete left ureteral obstruction and continued tubular reabsorptive activity of the obstructed kidney, or pyelovenous circulation.

Antegrade pyelography was also of value in a number of cases where the diagnosis was suspected or fairly well demonstrated by other methods. Among these were surgical trauma to a ureter, ureteral tumor, and obstruction by scar formation at the site of a ureterosigmoidostomy. Other applications are suggested. A natural outgrowth of the technic is translumbar needle nephrostomy, in which polyethylene tubing has been inserted through a large needle as a means of temporary urinary diversion.

[The authors were awarded first prize for this paper in an essay competition sponsored annually by the American Urological Association.]

Ten roentgenograms; 3 drawings; 1 photograph; 1 table.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Gas in the Urinary Tract. H. P. Kent. J. Fac. Radiologists **7**: 57–65, July 1955.

Three reports of urinary-intestinal fistulas and one of primary pneumaturia of the bladder call attention to the poorly recognized radiological finding of gas in the urinary tract.

Fistulas are most commonly located between the bladder and intestine, and in about one-third of cases are due to diverticulitis of the colon. Neoplasms, trauma, and congenital abnormalities account for the rest. Renovisceral and ureterovisceral fistulas are uncommon. Symptoms classically include passage of urine per rectum or intestinal contents per urethra.

Spontaneous gas formation occurs in the bladder, and more rarely in the kidney, from infection by gas-forming organisms. Symptoms are those of cystitis.

In most cases, gas cannot be visualized radiographically within the urinary tract, even when present clinically. When it is observed, the diagnosis of a fistula is important, although its actual demonstration by pyelograms or barium enema is usually of secondary importance. Diagnosis of spontaneous gas formation within the urinary tract should be offered only if fistula can be reasonably excluded. Intravesical gas calls for consideration of pneumatosis of the bladder in differential diagnosis. Here the abdominal flat film may show a concentric radiolucent ring outlining the bladder wall. A relationship between the two conditions has never been established.

Nine roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Renal Arteriovenous Fistula. Jack W. Schwartz, Anthony A. Borski, and Edward J. Jahnke. Surgery **37**: 951–954, June 1955.

A case of renal arteriovenous fistula in a 27-year-old woman is presented. The patient had had a right nephrectomy for pyonephrosis in 1949. Two years later she began to complain of exertional dyspnea and a constant severe left lower quadrant pain. Because of this pain she had two exploratory operations: in 1951 a bilateral salpingectomy was performed and in 1952 an ovarian cyst was removed. In 1953, a diagnosis of endometriosis was made and x-ray castration was carried out. In the next nine months the patient was hospitalized four times with severe left lower abdominal pain, vomiting, and distention. No cause for her complaints was discovered, and a diagnosis of psychoneurosis was made.

On admission to Walter Reed Hospital in February 1954, examination revealed moderate non-radiating left lower abdominal tenderness but no palpable abdominal masses. A definite thrill was present over the right lumbar region. On auscultation a harsh, machinery-like murmur was heard over the right flank scar, with greatest intensity a hand breadth to the right of the second lumbar vertebra. Findings on excretory pyelography were normal except for absence of the right kidney. Aortography was performed three times before satisfactory visualization was obtained. The final aortograms revealed a normal left renal artery and kidney; on the right, at the level of the right renal artery, was a 2-cm. collection of contrast medium with passage into and outlining the inferior vena cava. These findings were consistent with the diagnosis of right arteriovenous fistula. For twenty-four hours following each aortographic examination the patient had excruciating left flank and left lower quadrant pain. She experienced immediate and complete relief of symptoms following surgical excision of the fistula.

One roentgenogram; 2 photographs.

Ureterocele. Report of an Unusual Case. F. Petrovčić and C. Dugan. Brit. J. Radiol. **28**: 374–377, July 1955.

The authors summarize the literature on ureterocele and report a case. Though generally regarded as congenital, ureterocele may be acquired. A long intramural portion of the ureter is considered a prerequisite by some. A narrow uretero-vesical orifice predisposes toward dilatation of the terminal ureter, which progresses to bulge into the bladder.

On cystography the ureterocele can be seen within the bladder as an oval, smooth filling defect. On the intravenous pyelogram, the contrast-filled lower ureter has a "cobra-head" appearance. The wall is sometimes manifest as a light ring between the contrast medium in the dilated lower ureter and that in the bladder.

In differential diagnosis one must consider simple eversion of the mucous membrane lining the lower ureter. Occasionally, prostatic hypertrophy or simple cystic dilatation of the lower ureter may simulate ureterocele. The condition is thought to be more common in females. Frequently, it coexists with a double ureter, as in the authors' case. Multiple stones are often seen within the ureterocele. It is not unusual for the more cephalad portion of the ureter to be dilated also.

Treatment consists in re-establishing proper drainage through the ureter without destroying the ureterovesical valve.

Four roentgenograms.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Oxalosis. Report of a Case with Review of the Literature. Henry G. Dunn. Am. J. Dis. Child. **90:** 58–80, July 1955.

Evidence from experimental chronic oxalate poisoning in animals would suggest that a disease in which oxalic acid accumulates in the body would cause oxalate deposits in the renal tubules. Such deposits have never been demonstrated in persons alleged to suffer from "oxalemia" but have been reported in children dying of renal failure, often after passing oxalate calculi in the urine. Two of these children were also shown to have extensive deposits of calcium oxalate in the bones, and one had a few clusters of such crystals in various viscera. The condition has been named oxalosis and has been attributed to an inborn error of metabolism in which oxalic acid is formed in excessive amounts and combines with calcium to form a relatively inert compound.

The disease is found predominantly in males and most commonly in children. The main symptoms in the terminal phase are always those of renal failure.

Scattered foreign opacities throughout the renal parenchyma are a characteristic finding and were already present in an infant who died at the age of five months. In addition, radiopaque calculi may occur in the urinary tract. Sometimes a characteristic structure with radiating spicules indicates that they consist of calcium oxalate.

In the case reported in this paper there were widespread changes throughout the skeleton that resembled those of osteitis fibrosa cystica and included such striking features as "Umbauzonen," subperiosteal rarefaction, and invisibility of the dental lamina dura. At four years of age the patient had hematuria, urinary infection and bilateral hydronephrosis, with multiple renal and ureteric calculi. At thirteen years of age she suffered two fractures after slight trauma and x-ray examinations showed generalized demineralization with multiple areas of bone destruction. Death occurred from renal failure at the age of fifteen. At autopsy, the renal pelves and calyces were full of calculi consisting of calcium oxalate with an admixture of protein. The renal parenchyma showed extensive deposits of crystalline material as well as pyelonephritis and focal calcifications. Large deposits of similar crystals were found in the bones, and a few clusters were present in the myocardium, pancreas, and thyroid. Analysis showed the crystals to consist of calcium oxalate monohydrate.

Four roentgenograms; 1 photograph; 9 photomicrographs.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

Thorotrast Residue in the Kidneys Thirteen Years after Retrograde Pyelography. Milan Svoboda. Zentralbl. f. Chir. **79:** 1930–1933, 1954. (In German)

In the case reported in this paper, plain abdominal roentgenograms, supplemented by intravenous urography, demonstrated band-like metallic shadows forming the contours of the renal pelves and calyces bilaterally. These were undoubtedly residual to Thorotrast urography in 1941, which had been followed by left heminephrectomy. Similar metallic shadows were noted in the lower kidney poles and paravertebrally, apparently representing the regional lymph nodes. Renal calculi, calcifications, and other conditions could be excluded by tomography.

The present findings were incidental to an x-ray examination on account of vague lumbar and left inguinal pains. Otherwise no untoward clinical sequelae are mentioned in the patient, a 28-year-old nurse.

ERNST A. SCHMIDT, M.D.
Hilo, Hawaii

MISCELLANEOUS

Clinico-Radiologic Syndrome of Ossification Located Within Post-Laparotomy Xypho-Umbilical Scars (with 6 Personal Cases). Franco Chiariotti. Radiol. med. (Milan) **41:** 625–638, July 1955. (In Italian)

Ossification in a post-laparotomy scar, though otherwise trivial, may under circumstances lead to a tragic result, as in the case of a physician, previously operated upon for intra-abdominal cancer, who committed suicide because he interpreted an induration in the scar as a recurrence (Tansini). The author discusses at length the various opinions offered, but thus far has found no satisfactory explanation for the appearance of metaplastic bone within incisional scar tissue. He reports 6 cases among 64 laparotomies, or about 9.5 per cent, though the occurrence is generally regarded as very rare.

Aside from local induration, there is pain on flexion of the spine and on squatting. The radiographic appearance is of heterotopic bone seldom containing lacunar areas; ring-shaped calcifications result from prolonged drainage procedures. The author recommends the following views of the abdomen: (1) anteroposterior, with slight obliquity to avoid superimposition of the spine over the ossified scar; (2) lateral upright, for proper localization; (3) lateral during flexion of the spine, to identify the relationship (and occasionally a neo-arthrosis) between the osseous plaque and the ensiform appendix.

Fifteen roentgenograms; 1 table.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Tuberculous Pathogenesis and Roentgenologic Visualization of Abdominal Lymph Nodes. G. Wilbers. Fortschr. a. d. Geb. d. Röntgenstrahlen **83:** 77–86, July 1955. (In German)

Tuberculosis is by far the most frequent cause for the appearance of calcified lymph nodes. A topographic classification of calcified abdominal nodes includes (1)

the *mesenteric* group, corresponding to a wide band extending from the right iliac fossa across the spine to the left upper quadrant at the level of L-2 or L-3. As the mesentery is freely mobile, these calcifications may change position from one examination to the next. The largest number of calcified mesenteric nodes are located in the ileocecal area. (2) The *upper abdominal* group consists of a pancreatico-duodenal and aortic chain; it begins at a paravertebral point to the right of T-10 or T-11 and crosses the spine to terminate paravertebrally to the left, one and a half to two interspaces higher. Calcified lymph nodes in this group do not change position on successive films. (3) The *pelvic* group comprises nodes distributed retroperitoneally along the large iliac and pelvic vessels.

On roentgenograms, calcified lymph nodes are seen as typical, irregular, bizarre, sharply circumscribed densities, usually conglomerated to give a patchy, ragged contour. Discoid shapes are also encountered and must be distinguished from (*a*) cold abscesses, which cover a larger area, are relatively homogeneous, and have smooth outlines. For differential diagnosis, the author lists, also, (*b*) the trabeculated aspect of calcified perihepatitis and perisplenitis and (*c*) the symmetrical, triangular outlines of calcified adrenals, (*d*) Pancreatic calcifications, at a lower level than the upper abdominal lymph node group, (*e*) splenic or hepatic phleboliths, (*f*) splenic and hepatic cysts (such as those caused by Ecchinococcus), (*g*) calcified gallstones, and (*h*) calcified histoplasmosis in the lung bases, are relatively easy to identify. In the projection of the pelvic inlet, one must consider (*i*) vascular calcifications, (*j*) uterine fibroids, (*k*) ovarian tumors (teratoma) or cysts, and (*l*) prostatic, seminal, ureteral, and vesical calculi. Mention is made of the exceedingly rare, but characteristic (*m*) calcified (tuberculous) ovarian tubes, which resemble two sea horses (*Hippocampus*), projected symmetrically in the space between the sacrum and acetabulum.

It is of interest that the author has assembled his material in a pediatric clinic and hospital. The ages of patients described in the paper vary from three to fourteen years.

Nine roentgenograms; 9 schematic drawings.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

TECHNIC

Radiographic Use of Lead E.D.T.A. in Man. N. Sapeika. Brit. M. J. **2:** 167–169, July 16, 1955.

The water-soluble chelated compound lead ethylenediamine tetra-acetic acid (lead E.D.T.A. complex) has been shown experimentally to be of value as a contrast medium for oral and parenteral administration (Sapeika: South African M. J. **28:** 759, 953, 1954; **29:** 108, 1955. Abst. in Radiology **65:** 145, 1955). The present report deals with investigations in man.

Satisfactory shadows of the esophagus were obtained with small amounts of the complex (used as "lead swallows"). For this purpose, the preparation was incorporated in a thick starch paste. Caution is necessary with oral administration of large quantities of lead E.D.T.A., however, because it produces black stools, presumably due to lead sulfide.

Intravenous administration of 15 c.c. of a 50 per cent solution of the lead complex produced renal shadows within three minutes, lasting for thirty to forty minutes. In 1 patient the results were equal to those after use of Diodone. It is suggested that the lead complex intravenously, perhaps with calcium E.D.T.A., may provide an alternative to iodine compounds for urography. Unlike iodides, lead E.D.T.A. does not give a reaction with the orthotoluidine test for blood. It did not produce diuresis.

In the nasal sinuses, shadows of good density were obtained with lead E.D.T.A. in a sodium chloride solution, and there was no immediate irritation or late reaction.

Five roentgenograms.

Experiences with High-Voltage Technic (Megameta 125) in Gastroenterological Roentgenology. Milan Svoboda. Vnitřní Lékařství **1:** 189–194, 1955. (In Czechoslovakian)

The maximum capacity of the new Czech-manufactured diagnostic machine described in this paper is 800 ma and 125 kv. Employing exposure times of 0.05 to 0.06 seconds (8 to 9 ma.), roentgenograms of the gastrointestinal tract were obtained which in the author's opinion were far superior to those produced by lower voltage technics.

ERNST A. SCHMIDT, M.D.
Hilo, Hawaii

RADIOTHERAPY

Radium and Surgery in Cancer of the Breast. Jan Kotaś. Acta radiol. & cancerol. bohemoslov. **8:** 216–225, September 1954. (In Czechoslovakian)

The author reports his experiences with radical interstitial radium application, according to Maisin's method (irradiation in conjunction with radical surgery. See J. de radiol. et d'électrol. **29:** 363, 1948. Abst. in Radiology **53:** 304, 1949), in 51 patients at the Masaryk State Institute of Radiotherapy at Brno (Czechoslovakia). The three-year survival percentage for all cases (more than one-half Stage 3) was 47.8 per cent. The treatment period included the years from 1947 to 1951.

Special emphasis is given to the potential dangers of this method of interstitial radium therapy both for patients and personnel. Although its value in certain types of breast cancer, under strict precautions, is indisputable, especially in advanced cases and in combination with operative procedures, its use should be restricted to larger institutions specializing in radium therapy, where the cases can be carefully selected and adequately supervised.

Two illustrations.

ERNST A. SCHMIDT, M.D.
Hilo, Hawaii

Adenocarcinoma of the Endometrium. An Evaluation of Factors Influencing Prognosis and an Outline of a Plan of Therapy Based on These Factors. Gilbert A. Webb, Alan J. Margolis, and Herbert F. Traut. West J. Surg. **63:** 407–416, July 1955.

There is an increasing incidence of recognized adenocarcinoma of the endometrium, possibly due in part to the increasing longevity of the population. This is predominantly a disease of the menopausal and postmenopausal period. Whereas the end-results in treatment of cervical carcinoma have improved in the last

few decades, results in fundal carcinoma have remained the same.

Clinicopathological study of 261 cases of adenocarcinoma of the endometrium has led the authors to propose a plan of therapy which may lead to improved end-results. All patients should be examined under anesthesia with curettage performed for tissue diagnosis. Every attempt should be made to operate upon as many patients as possible but, when the patient is inoperable from a medical standpoint, either intracavity radium alone or in combination with external roentgen therapy is indicated. When the uterus is small, intracavity radium is given with a tandem. When the uterus is large, the packing technic is employed.

Surgery alone is advocated where there is a small uterus with a well differentiated carcinoma. If deep myometrial invasion is found, external therapy is given postoperatively.

For a small uterus with intermediate or fully differentiated carcinoma, preliminary treatment with radium is followed in six weeks by total hysterectomy. If positive lymph nodes or deep myometrial invasion is found, postoperative roentgen therapy is given.

For a large uterus with well differentiated carcinoma, preliminary radium treatment with the packing technic is followed by hysterectomy after four to six weeks. If positive lymph nodes are found, external roentgen therapy is employed.

For extension to the cervix, the combination of radium and surgery must be supplemented by external roentgen therapy. For extrauterine spread, surgical treatment depends upon the judgment of the surgeon. It should be supplemented by roentgen irradiation.

Possibly too much attention has been given to five-year-survival statistics and insufficient attention to ten- and fifteen-year results.

Six tables.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

Malignant Disease of the Ovary and Radiotherapy. A Survey of 168 Cases with 10-Year Follow-up. Frank Ellis. J. Fac. Radiologists **7:** 1–10, July 1955.

One hundred sixty-eight cases of malignant disease of the ovary which were seen at the Sheffield Radium Center (England) are reviewed after a ten-year follow-up. Cases were classified both as to degree of spread and histology. Ascites in cases with involvement of only one ovary did not seem to be of unfavorable prognostic significance, but was of grave import where extension went beyond the ovary. Similarly, involvement of both ovaries did not indicate a serious prognosis where complete removal was possible, but had significant implications when removal was not possible. Histologically, when epithelial ovarian tumors showed stromal invasion, ten-year survival rates dropped from 74.4 per cent (for those without stromal invasion) to 15.4 per cent.

In the author's experience with these cases abdominal pain seemed to be the most serious symptom; often this was referred to the upper abdomen. Abdominal swelling was the symptom most suggestive of ovarian tumor.

The rationale of treatment is discussed at length. In patients under forty, only the affected ovary should be removed unless the tumor is obviously malignant. If complete removal of the growth does not demand hysterectomy, the uterus should be left *in situ* for the application of radium within the pelvis.

The author's recommendations for radiotherapy have not yet been proved by results. In all cases of ovarian cancer except dysgerminoma, intracavitary radium therapy is suggested, in the amount of about 3,000 mg.-hr. External radiation therapy should be used up to the maximum clinical tolerance. In dysgerminoma a dose of about 1,500 r given by external beam radiation should be sufficient. External radiation therapy is also recommended for treatment of the para-aortic lymph nodes from 1 inch below the umbilicus up to the sternal xiphoid.

If ascites is present without thick peritoneal metastases, 150 to 200 mc of radioactive colloidal gold should be given. With thick peritoneal deposits, 2,400 r should be given by external radiotherapy to the abdomen in six weeks time, through wide portals.

Preoperative radiation therapy probably has merit. Two thousand roentgens in three weeks would seem to be a reasonable dose.

Three figures; 10 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Survey of Cases of Carcinoma of the Ovary Treated in the Radiotherapy Department, London Hospital, 1943–1950. Walter Shanks. J. Fac. Radiologists **7:** 11–17, July 1955.

In this review of 170 cases of ovarian cancer, as in the series reported by Ellis (see preceding abstract), pain was the predominant presenting symptom. Other symptoms in order of frequency were tumor, abdominal enlargement, abdominal discomfort, and vaginal bleeding.

Not all patients undergoing panhysterectomy were given postoperative x-ray therapy, but those cases receiving incomplete surgery were commonly referred for follow-up irradiation. This was administered through wide ports over the abdomen, with about 3,000 r tumor dose to the whole abdomen and pelvis in five weeks. With the peripheral blood picture as a guide, treatments were stopped prematurely if anemia or leukopenia developed. The use of radium by the Stockholm technic, subsequent to x-ray therapy, was thought to minimize recurrence in the vaginal vault and pelvis.

It appeared that if a full postoperative course of radiation therapy was given, it made little difference whether panhysterectomy or complete local removal were performed. The crude three-year survival rate was about 55 per cent.

If postoperative radiation therapy was given after incomplete removal of the primary tumor, the crude three-year survival rate dropped to about 42.5 per cent. Where postoperative irradiation was inadequate, there were no three-year survivors.

The main cause of death in the series was carcinomatosis peritonei with cachexia.

Three figures; 5 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Radiologic Aspects of Pancreatic Fistulae. William W. Bryan and J. Frank Walker. South. M. J. **48:** 701–709, July 1955.

The basic physiology and management of external pancreatic fistulas are reviewed with particular reference to the role of radiotherapy. It has been suggested that the value of irradiation consists largely in tempo-

rary inhibition of the function of the pancreas, thereby providing an opportunity for the fistulous tract to close spontaneously. The use of high-voltage x-ray therapy in 5 patients with external pancreatic fistulas is reported, with closure of the fistula occurring in 4. Although the lesion persisted in the fifth, a marked decrease was noted in the amount of pancreatic secretion, with no evidence of subsequent autolysis or erosion of the tissues of the abdominal wall.

Ten roentgenograms.

Giant Cell Tumor of the Maxilla in a Young Child. A. P. Keller, Jr., James J. McDonald, and James B. Allen. J. M. A. Georgia **44:** 353–354, July 1955.

A case of extensive giant-cell tumor of central type, occurring in the maxilla of a six-year-old boy, is presented. In a review of the literature for the past twenty years, the authors found no report of this tumor in so young a child. It is considered that this case demonstrates the advisability, in certain circumstances, of x-ray therapy followed by operation rather than the reverse. Substantial reduction of bleeding at surgery is attributed to preoperative irradiation employed in this patient. It is believed that surgery of extensive giant-cell tumors thus may be greatly simplified.

Biologic Fundamentals and Recent Concepts in Inflammatory Irradiation and Functional Roentgen Therapy. Eberhard Scherer. Strahlentherapie **97:** 349–361, July 1955. (In German)

The generic term "irritative or stimulative (*Reiz*) roentgen therapy" covers both the *regional* or *general* effect of radiation, and its *local* antiphlogistic and/or analgesic action.

The antiphlogistic and analgesic effect of roentgen rays, known since 1897, seems to shorten the course of inflammation, particularly when applied at the height of the acidotic reaction. It will either prevent suppuration (with shift toward an alkaline *p*H), or hasten necrosis, with ultimate restoration. In chronic inflammations, relief is usually obtained only after an initial period of reactivation. In this connection, mention is made of the method of Pape (Vienna), who treats inflammations with doses of 1 to 20 r. It is believed that increased resistance to radiation can also be produced in this way, since animals which received 0.25 r daily for one hundred days showed longer survival rates and lesser histologic changes in the genitals after massive irradiation than previously untreated controls.

The author notes, with regret, that sulfa drugs and antibiotics have largely curtailed the use of x-rays for inflammatory processes, but resistant microorganisms make antibiotics useless, and in such cases radiotherapy may be of help, perhaps even life-saving.

While irradiation for inflammatory processes is always locally applied, in the case of functional treatment, the attack may be directed (*a*) to the hypothalamus; (*b*) to the skin, in the hope of causing irritation with distant response; (*c*) to the major nervous channels, adjacent nerve ganglia, and periarterial autonomous ramifications.

A representative grouping of conditions for which "functional" roentgen therapy has been recommended includes: (1) angioneuroses (acrocyanosis, Raynaud's disease, scleroderma, ulcus cruris, acroparesthesia); (2) organic vascular diseases (arteriosclerosis, endangiitis obliterans with ulcer formation); (3) neurovascular disturbances (anuria or oliguria after crush syndrome or severe glomerulonephritis, painful spasms associated with cholelithiasis and nephrolithiasis, chronic constipation caused by megacolon or brain tumor; essential hypertension, etc.); (4) skin conditions associated with pruritus, including eczema; (5) allergic conditions of all categories; (6) endocrine disorders (irradiation of the thyroid and thymus in hyperthyroidism; of the pituitary in isolated malignant exophthalmos, Cushing's syndrome, acromegaly, and mongolism; of the ovary in ovarian insufficiency, etc.); (7) nervous illnesses, either peripheral (neuritis, neuralgia, herpes zoster) or central (post-traumatic conditions); (8) traumatic, degenerative, and deforming joint diseases.

One table.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

The Distribution of Dose-Rate Across the Field of an X-ray Therapy Tube. R. F. Farr. Brit. J. Radiol. **28:** 364–373, July 1955.

It is common in x-ray therapy to employ radiation beams of considerable width, frequently up to 25 cm. If one checks the tube output in air in various portions of the beam at different distances from the central ray, considerable variation will be found.

Studying 5 different therapy machines, the author made measurements perpendicular to the axis of the tube (perpendicular to the line between the anode and the cathode) and found fairly symmetrical fall-off on both sides of the beam. However, measurements made parallel to the tube axis showed wide variations from one end of the beam to the other, depending upon the angle with which the target sat in the tube.

With a rather steep angle, there is absorption within the target material of x-rays which are generated at a depth within it. This "heel" effect produces a fall of dose rate from the front to the back of the beam. In addition, the differences in the filtration of the therapy beam and the voltage of the tube make a considerable difference in the dose distribution parallel to the tube axis.

It has been found that the optimum target angle is about 45° for 3 mm. Al h.v.l., 30° for 0.5 mm. Cu, and somewhat less for 1.7 mm. Cu. A compensating filter for a 20° target, to correct for the unsatisfactory dose distribution, has been designed and used by the author for four years. With this, the variation of dose rate is kept within 10 per cent across a field of 25 cm. diameter at 50 cm. target-skin distance.

Fourteen figures; 3 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Errors in Dosage Indication with Indirect Measurement Procedures in Deep Roentgen Therapy. R. Huber. Strahlentherapie **97:** 444–451, July 1955. (In German)

It is common usage to calculate tissue doses from one of the better known tables (Quimby, Mayneord, Grebe) by using as a basis the more or less regularly measured output of the installation in r/min. In this way, several errors may be introduced in the calculation:

1. The depth of the irradiated structure beneath the skin surface is often improperly evaluated, or it may be altered by more or less heavy compression; a difference of ±1 cm. may mean a variation of as much as ±15 per cent of the tissue dose.

2. The contribution of angulated ports (in cross-fire technics) is calculated from the totally inadequate values obtained in measurements of perpendicular fields in phantoms; errors in angulation, the added backscatter, and overlapping ports may be responsible (conservatively) for a difference of 20 per cent in the tissue dose.

3. The ionization density effected by 200-kv radiation depends upon the specific density of the tissues penetrated, but the fall-off thus caused is most often totally disregarded. Bone may attenuate the beam by as much as 40 per cent. Conversely, in the esophagus the dose may be raised to 100 per cent beyond the calculation, because the air-filled lungs have a minimal absorption coefficient; this makes estimation of tissue for a centrally located organ in the skull, thorax, abdomen, or pelvis very inaccurate. Equalization of the absorption coefficients of the various tissues occurs between 400 kv and 2 MEV.

4. The time factor is of definite importance, *i.e.*, there is need for a "tissue dose of constant intensity." In this respect, additional studies are necessary.

5. The output of the tube may change, due to slight deterioration of the focal spot (failure of the cooling system with consequent overheating) or transitory variations of the electrical power.

In conclusion, the author recommends that installations be checked by intercalating a permanent monitor between tube and patient, and that, wherever feasible (esophagus, bronchus, stomach, uterus, vagina, etc.), the dose be measured directly with small thimble chambers, or at least calculated on the basis of determinations made on water phantoms which include bone structures for adequate attenuation of the beam.

Seven graphs; 1 photodiagram; 1 table.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Calculated Depth Dose Curves in Tissue for Broad Beams of Fast Neutrons. Walter S. Snyder and J. Neufeld. Brit. J. Radiol. **28:** 342–350, July 1955.

When tissue is irradiated by fast neutrons with energies extending up to 10 MEV, the neutrons lose their energy primarily by elastic collision with the atoms composing the tissue. The struck atoms acquire kinetic energy, which in turn is dissipated by ionization, excitation, and elastic collisions with other atoms. More rarely, a nuclear reaction takes place which results in the emission of a gamma ray, a proton, or an alpha particle. The recoil atoms, protons and alpha particles lose their energy within a small fraction of a centimeter of the point of collision, and thus the energy imparted by a neutron may be considered absorbed at the collision site. Since the cross section for absorption of fast neutrons is very small, gamma rays do not contribute substantially to the dose received by the tissues while the neutrons are slowing down.

In analyzing the dose to tissue, it is useful to consider the total dose as consisting of the dose administered by the neutrons during the process of slowing down to thermal values (hereafter referred to as the "fast dose") and the dose produced by the neutrons after they reach thermal energy in the tissue (the "thermal dose"). For the fast dose, the energy lost by neutrons in slowing down is absorbed near the points where the neutrons collided with the tissue atoms; whereas the energy producing the thermal dose may be absorbed in the tissue at great distances from the point of release. For neutron energies of the order of 1 MEV or more, the thermal dose is always a minor part of the total dose, but for lower energies it must be taken into account.

The technicalities of calculation of the fast dose and the thermal dose are discussed by the authors, and numerous curves plot energy absorption from neutron beams ranging all the way from 5 KEV up to and including 10 MEV. There also is a chart showing energy absorption from thermal neutron beams. In addition, depth dose charts accompany each of the others. These too show that, in the lower energies, the thermal neutron component of the depth dose becomes more important.

Thirteen graphs; 8 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Measurements of Neutron Dose as a Function of Linear Energy Transfer. Harald H. Rossi and Walter Rosenzweig. Radiation Res. **2:** 417–425, July 1955.

An analysis is presented of the tissue dose delivered at three types of neutron sources. The analysis is one in which the portion of the dose delivered at any value of LET (linear energy transfer) is determined. The instrument employed is a spherical proportional counter that has been previously described. The pulse-height spectrum obtained with this device is evaluated by a mathematical procedure that yields the LET spectrum. The sources studied were Pu-Be, Po-B, and 3 MEV neutrons from the $H^2(d,n)He^3$ reaction.

The experimental curves obtained are compared with theoretical data supplied by Boag. The discrepancies are rather unimportant so far as direct radiobiological applications are concerned. It is noted, however, that the divergence may be due to the fact that the theory neglects statistical fluctuations in energy loss.

Five figures. AUTHORS' ABSTRACT

RADIOISOTOPES

Study of the Index of Conversion of Radioactive Iodine as a Test of Thyroid Function. L. L. Barbieri. Schweiz. med. Wchnschr. **85:** 648–650, July 2, 1955. (In French)

The transformation of inorganic iodide into organic iodide (bound to albumin and a_1-globulin) occurs in direct relation to function of the thyroid. Following administration of a tracer dose of 200 microcuries the rate of conversion was determined at twenty-four, forty-eight, and seventy-two hours. In *euthyroid* individuals the conversion rate varies after twenty-four hours from a minimum of 7 per cent to a maximum of 40 per cent, with a mean of 17.9 per cent. After forty-eight hours the mean value rose to 81.7 per cent, and after seventy-two hours, to 95.5 per cent. In *hyperthyroidism* the mean value is 72.2 per cent after twenty-four hours, and a maximum value of close to 100 per cent is attained at forty-eight hours. In *hypothyroidism* the mean value is 2.3 per cent at twenty-four hours, and remains low at forty-eight and seventy-two hours.

In neurovegetative conditions, sympathicotonia and vagotonia, basal metabolic rates are normal. In sympathetic preponderance the rate of conversion is higher than in normal subjects but lower than in hyperthyroidism. In vagotonic individuals the rate is normal.

Four graphs.

CHARLES M. NICE, JR., M.D.
University of Minnesota

Uptake and Blood Level of Radioactive Iodine in Hyperthyroidism. Robert A. Newburger, Solomon Silver, Stephen B. Yohalem, and Sergei Feitelberg. New England J. Med. **253:** 127–130, July 28, 1955.

The comparative diagnostic values of the measurement of thyroid uptake and the determination of the plasma level of protein-bound iodine in hyperthyroidism were shown in a series of 96 untreated hyperthyroid and 404 euthyroid patients. Thyroid uptake was determined at twenty-four hours and protein-bound iodine plasma level at seventy-two hours following oral administration of 25 to 100 microcuries of carrier-free I^{131}.

The uptake method showed a diagnostic error of 7.2 per cent; with the blood level method the error was only 1.6 per cent. This means a lowering of the "worst" error (20 per cent) by a factor of 12, as compared to a lowering by only a factor of 3 in the uptake method. Calculations were based upon critical diagnostic values of 61 per cent uptake and 0.26–0.27 per cent of the administered dose per unit of plasma, derived from frequency distribution charts of the cases studied.

Selection of a critical range for thyroid uptake (42 to 69 per cent) reduces the diagnostic error to 1.6 per cent. However, this leaves 127 patients or 27 per cent of the total number of cases unclassified, whereas with the plasma-level method, the same percentage of accuracy was obtained, with no unclassified cases.

Three graphs.

JULIO O'LACO, M.D.
Mercy Hospital, Pittsburgh

Radioiodine Uptake in Children with Mongolism. Abraham Friedman. Pediatrics **16:** 55–66, July 1955.

The author presents the results of radioactive uptake studies in 61 children with mongolism and in 68 euthyroid children with mental retardation, as performed at the Radiation Center of the Cook County Hospital, Chicago. The radioiodine uptake in mongoloid children did not differ statistically from that of the mentally retarded euthyroid children.

Of interest is the fact that, although the tests were performed only ten to fourteen days after cessation of administration of thyroid medication in most of the mongoloid cases, these patients still showed the same general uptake distribution as normal untreated controls. The low dosage to the mongoloids may account for this situation.

The fact that there is statistically no difference between the mongoloid and euthyroid groups would rule out hypothyroidism, either primary or secondary to hypopituitarism, as a factor in mongolism.

Two graphs; 3 diagrams; 4 tables.

JOHN F. BERRY, M.D.
University of Louisville

The Response of the I^{131}-Treated Thyroid Gland to Thyrotropic Hormone. Jorge M. Martin and John B. Stanbury. J. Clin. Endocrinol. **15:** 811–817, July 1955.

In 12 patients I^{131} uptake and the serum concentration of protein-bound iodine were determined prior to and following administration of thyrotropin. Each patient had been thyrotoxic and returned to the euthyroid, or moderately hypothyroid, state by means of I^{131} therapy. Six clinically euthyroid patients with normal serum concentration of protein-bound iodine and normal thyroidal I^{131} uptake served as controls.

The patients treated with I^{131} could be divided into three groups on the basis of thyroid function:

(1) The functional activity of the thyroid glands of some was reduced by I^{131} to the degree that they failed to maintain a normal serum concentration of protein-bound iodine or a normal I^{131} uptake. The glands of these patients showed little or no response to stimulation by thyrotropic hormone. (2) These patients were able to maintain a normal serum concentration of protein-bound iodine and normal thyroid uptake of I^{131} but failed to respond to thyrotropic hormone. (3) The third group of I^{131}-treated patients had normally functioning thyroid glands which responded vigorously to thyrotropic hormone.

The explanation suggested is that the remnants of thyroid tissue in Groups 1 and 2 were functioning at maximal capacity and were unable to respond to further thyrotropin, above that derived from their own glands. The possibility that I^{131} in some way impairs the capacity of the thyroid cells to respond to thyrotropin is not, however, excluded.

Two graphs; 1 table.

JOHN F. WEIGEN, M.D.
Palo Alto, Calif.

The Destructive Effects of Radioactive Iodine. J. A. Forbes. Brit. J. Radiol. **28:** 378–380, July 1955.

By administering radioactive iodine to rats bearing carcinoma transplants, the author of this article was able to demonstrate that the destructive effect of radioiodine was confined to rather well differentiated thyroid-like tissue, and had no apparent effect on undifferentiated tumor tissue or mitotic cells.

Whereas complete ablation of the thyroid gland was produced by large single doses of I^{131}, tumor tissue was destroyed in a patchy, uneven manner, so that repeated doses would appear to be necessary in the treatment of tumor. Tissues which were irradiated in this manner showed practically no inflammatory reaction or hemorrhage.

The effect of I^{131} is to destroy functional tissue and, in so doing, to reduce the total volume of secretion. It may thus be possible to delay the enlargement of a differentiated tumor or to reduce its size.

In pulmonary metastases, the bronchi were found to be one route by which radionecrotic debris is expelled. This suggests a possible hazard in treatment.

One photomicrograph; 1 radioautograph.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Radiation Sickness in Man Following the Administration of Therapeutic Radioiodine. Relationship Between Latent Period, Dose-Rate and Body Size. John D. Abbatt, W. M. Court Brown, and H. E. A. Farran. Brit. J. Radiol. **28:** 358–363, July 1955.

Radiation sickness quite often follows the administration of radioactive iodine. This sickness rather closely resembles that which follows a single exposure to x-rays of medium voltage. There are two main differences: First, the latent period between the time of administra-

tion of the radioiodine and the appearance of the sickness is longer than in the reported x-ray groups. Secondly, the radiation doses are lower.

The authors review the histories of 38 patients who received I^{131}. Radiation sickness was observed in 28. By plotting the administered activity against the total body surface and against body weight, it was possible to obtain reasonable estimates as to the total-body irradiation. It was found that there was no apparent relationship between the radiation sickness and the amount of uptake within the thyroid gland. The symptoms rather appeared to be related to the total-body dose.

The symptomatic disturbance consisted primarily of fatigue, headache, nausea, and occasionally vomiting. There appeared to be two phases of the illness. The first occurred within twenty-four hours of the radioiodine administration; the second occurred between the fifth and ninth days, but developed in only 11 of the 28 patients in whom initial symptoms were noted. The symptoms were similar to the earlier ones but usually less severe. A number of patients noted a radiation thyroiditis, with tenderness of the thyroid gland on swallowing and on palpation, but this appeared to be unrelated to the symptoms of radiation sickness.

The latent period after radioiodine administration ranged from between four and thirteen hours, whereas the latent period after medium voltage x-rays has been described as being between two and five hours after administration. It appears likely that the dose rate, as well as the total dose, is important in the production of radiation sickness.

Five figures; 2 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Radiation Dosimetry in the Treatment of Carcinoma of the Cervix Uteri by Intraparametrial Radioactive Gold and Radium. Michel Ter-Pogossian and Alfred I. Sherman. Am. J. Roentgenol. **74:** 116–122, July 1955.

On the basis of extensive studies over the last few years it appears established that in the radiation treatment of carcinoma of the cervix uteri adequate dosage is in general being given to the local lesion but that the dose to the parametrial tissues is frequently inadequate. In about 25 per cent of reported Stage I and II cases, positive lymph nodes are being found in the parametria at surgery.

The authors have previously studied this problem by injecting a colloidal suspension of radioactive gold into the parametria and observing its concentration in the lymph nodes (Cancer **6:** 1238, 1953. Abst. in Radiology **63:** 623, 1954). In the present paper they consider the radiation dosimetry of intraparametrial radioactive gold plus intracavitary radium.

As a preliminary, 10 female cadavers were dissected, the critical nodes and cervix were identified by metal clips, and roentgen studies were made to determine the relation of the node-bearing areas to the bony pelvis. Patients were then given radioactive gold mixed with Diodrast into each parametrium; roentgenograms were obtained immediately, and the diffusion of the injected gold was followed for two weeks with a scintiscanner. These studies indicated that the lymph node-bearing areas as determined in the cadaver fell well within the confines of the volume occupied by the gold. The latter could be approximated roughly by two spheres of 500 c.c., 10 cm. in diameter, centered at Points B of the Manchester system.

With 70 c.c. of colloidal gold injected into each parametrium the estimated dose contributed by the beta rays is approximately 10,600 rep. The gamma contribution was measured by a scintillation probe counter in a series of 20 patients, of whom 5 were subsequently submitted to laparotomy. It was found to be 2,250 r to the mid-parametrium, which, added to the gamma roentgens contributed by the intracavitary radium, gives a total of 5,600 gamma r. Doses to other pelvic structures from the radium and other radioactive sources are presented in a table.

Seven roentgenograms; 1 table.

WILLIAM SNOW, M.D.
Shreveport, La.

Experiences in the Use of Radio-Active Colloidal Gold in the Treatment of Carcinoma of the Ovary. Charles L. Lewis. J. Fac. Radiologists **7:** 17–19, July 1955.

At United Oxford Hospitals, the use of Au^{198} intraperitoneally has been included part both of radical and palliative treatment of ovarian carcinoma. Between May 1951 and November 1953, 19 of 45 cases received gold as part or all of their treatment. Treatment disturbed the patients very little, causing only mild nausea without vomiting.

Treatment with gold was felt to be indicated in cases where surgical spill of malignant cells into the peritoneum was thought to have occurred, where free fluid was present in the abdomen in the absence of gross metastases, and where small peritoneal implants were actually found at operation. Serous-cell carcinomas, papillary cystadenocarcinomas, serous and pseudomucinous cystadenocarcinomas have been handled in this manner.

Results generally appear good, with the hoped-for effects following the use of the gold in a fairly high number of patients. The gold served to control ascites in 7 cases which have been followed for more than a year. In a few instances where free fluid or tumor spill were encountered at surgery, postoperative injections of gold have apparently prevented development of recurrences. Of 8 further patients who have been followed less than a year, only 2 have any suspicion of growth, and none have ascites.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Treatment of Cancer of the Bladder by Radioactive Cobalt. Egon Wildbolz and Guelfo G. Poretti. J. Urol. **74:** 93–103, July 1955.

The authors treated 42 cases of cancer of the bladder with radioactive cobalt according to the method used by Müller (Strahlentherapie **85:** 87, 1951). Thirty millicuries of $CoCl_2$ in 50 c.c. solution were introduced into a bag catheter in the bladder and left in place for ten days. The total dose at the surface of the catheter was 30,000 r, giving a depth dose at 1 inch of approximately 25 per cent, or 7,500 r, to the tumor's pedicle. This dose is considered to be the maximum permissible for the uninvolved bladder mucosa and causes some reaction in every case. An exchange of ions was found to take place through the rubber wall of the catheter, but active Co^{++} ions were found never to exceed 10^{-4} microcuries per liter in daily checks of the urine for

radioactivity. In only 1 case did an extremely small amount of active ions reach the blood stream, amounting to 1 microcurie. The patients were treated in a room as isolated as possible. Radiation received by attending personnel, as measured by pocket dosimeters and film badges, never exceeded half the daily tolerance of 60 mr, even when the patient required a great deal of care.

For palliation this method of treatment was found to be ineffective. For large tumors also, cobalt therapy alone appeared inadvisable. A combination of surgery and radiation proved to be more effective. All the exophytic parts of the tumor were removed, either transurethrally or by cystotomy; partial resection of the bladder was carried out if indicated. Cobalt radiation was administered postoperatively, usually after healing of the wound. The only hospital death in the series occurred in a patient three weeks after the treatment, from perinephric abscess in a single kidney, and uremia.

Side-effects occurred almost invariably. About the sixth day of treatment, irritation would arise in the urethra from the indwelling 22 F catheter and in the bladder from radiation. Toward the end of treatment a disagreeable proctitis sometimes developed. The symptoms usually subsided within a week of conclusion of treatment. In 3 cases severe suffering and incapacity continued for months. Two of these patients were found, after a fatal outcome, to have persistent cancer rather than a radiation reaction. The use of the catheter was felt to be mandatory, to prevent distention of the bladder as a result of retention due to spasm, which would reduce the dose received by the tumor because of increased distance from the source of radiation.

The authors see certain drawbacks in cobalt therapy for bladder tumors. For one thing, the radioactive solution is dangerous to handle. In spite of every precaution in the use of the cobalt, in one patient the balloon containing the solution broke shortly after a partial resection of the bladder. The accident went unnoticed for a few hours and resorption occurred through the wound. The blood remained radioactive for two days; elimination was by way of the bowels and the urine. The patient had a very stormy convalescence but recovered, and two years later was found to have no residual ill effects.

A second drawback is lack of selectivity. The authors hope to devise a method which will deliver less radiation to the normal parts of the bladder without reducing the dose to the tumor.

Six of the 42 patients appeared cured after short follow-up periods, ranging from six months to three years. The apparent cure rate of 15 per cent is a tentative figure, but compares well with the results of total cystectomy.

Six roentgenograms; 1 graph; 1 photograph.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Use of Radioactive Cobalt (Co_{60}) in Treatment of Bladder Tumors. Vincent Vermooten. J. Urol. **74:** 85–92, July 1955.

The author previously reported a method of treating carcinoma of the bladder by sewing through the tumor nylon sutures containing radioactive cobalt (J. Urol. **73:** 280, 1955. Abst. in Radiology **65:** 963, 1955). The nylon tubing had a wall 0.25 mm. thick, which was sufficient to filter out 93 per cent of the beta radiation and make the material, for all practical purposes, a pure gamma emitter. The strands were sewed, at suprapubic cystotomy, into the neoplasm in parallel rows about 1 cm. apart, left in place long enough to give a calculated tumor dose of approximately 8,000 r, and then removed after about one week.

The present article contains a follow-up on a patient with extensive infiltrating carcinoma of the bladder reported in the author's previous article. Two years after his treatment he had a normal appearing and normally functioning bladder without evidence of carcinoma. Papanicolaou stains of the urine sediment revealed no malignant cells. The bladder capacity increased after treatment from 75 c.c. to 350 c.c.

Five other cases of carcinoma of the bladder treated by the method are presented here. Four of the patients responded well and were essentially free of symptoms when seen two to five months after operation. The other died of uremia after eleven months. Autopsy showed residual carcinoma in the prostate, base of the bladder, and perivesical tissue. The patient who had a fatal outcome experienced severe radiation cystitis. It is possible that he received more intensive radiation than was calculated because he did not have a 30 c.c. balloon catheter in his bladder as most of the others did. In 1 other patient in whom mild radiation cystitis developed, the balloon catheter had been removed after two days in order to provide a better cobalt pattern (as determined by x-ray examination) for effective irradiation.

Three roentgenograms; 5 photomicrographs.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Clearance of Radioactive Dust from the Human Lung. Roy E. Albert and Lawrence C. Arnett. Arch. Indust. Health **12:** 99–106, July 1955.

The authors describe an investigation of the effective biological half-life of thoron daughters in the lungs and the clearance rate of radioactive dust by ciliary action.

The effective half-life of thoron daughters in the lungs, following deposition together with kaolin particles of mass-median diameter 1.1–1.3 μ, was found to be about nine hours. This value is very close to the radiological half-life of 10.6 hours, indicating that the biological half-life is in the order of sixty hours. This study shows that, once deposited, the thoron daughter products and, by analogy, radon daughter products (because their chemical forms are almost identical) are removed slowly enough that the effective half-life is not significantly different from the rate of radiological decay.

The early bronchial clearance of radioactive iron particles from the lungs appeared to have two phases, the first clearance period ending in two to four hours and the second in about thirty hours. There is little doubt that the initial rapid removal represents ciliary clearance. The larger the average inhaled particle size, the greater the fraction removed in two to four hours.

The results obtained with the thoron daughter experiments are probably more representative of particles deposited mainly in the alveoli, and consequently it is still undetermined whether radon or thoron daughters would be cleared by the ciliary mechanism. It is worth noting that, because the radioactive daughters are fixed to the surfaces of particles, their distribution in a

dust cloud will tend toward the smaller particles, where the surface area is greatest, and these are the ones which would tend to be deposited in the alveoli. This is to be contrasted with the radioactive iron particles, in which the amount of radioactivity is a function of mass rather than of surface area.

Eight figures

Distribution, Retention, and Elimination of Be^7 in the Rat After Intratracheal Injection. C. D. Van Cleave and C. T. Kaylor. Arch. Indust. Health **11**: 375–392, May 1955.

Female rats, weighing approximately 160 to 180 gm., were injected intratracheally with 0.3 to 0.8 ml. of a saline solution containing radioactive beryllium, Be^7, in the form of Be^7SO_4 or Be^7 citrate. By serial killing of the injected animals at intervals of one to three hundred fifteen days, the retention of the injected Be^7 in the lungs and the distribution and elimination of the mobilized fraction were followed and compared. Separate urine and feces determinations were done on selected groups for sixteen days, and others followed at intervals up to one hundred twenty days.

Deposition of Be^7 within the lobe of the lung was followed by means of radioautographs and found to be irregular and non-homogeneous.

Citrated Be^7 was almost completely mobilized from the lung at four days, 79 per cent of the original dose being eliminated in that time in urine and in feces; the skeleton contained more than one-half of the total retained activity.

Some Be^7SO_4 preparations were mobilized from the lung at a rapid rate after sixteen days, with a concomitant increased deposition in mediastinal lymphatic structures. Other Be^7SO_4 preparations were still retained in the lung in appreciable amounts at three hundred fifteen days.

Excretion by way of the kidneys was always high in the first twenty-four hours, then dropped to a low level, becoming undetectable after seventy-five days. Elimination of Be^7 in feces was persistent for a known period of forty days and during this period surpassed kidney excretion in total amount.

The relation of these data to lung clearance and anatomical routes of mobilization from the lung is discussed.

Twenty-four radioautographs and photomicrographs.

RADIATION EFFECTS

Effects of Million Volt Irradiation on the Gastrointestinal Tract. Irving B. Brick. Arch. Int. Med. **96**: 26–31, July 1955.

The author reviewed some 230 records to evaluate the effects on the gastrointestinal tract of supravoltage (1,000 kv) irradiation to the lymph node areas for testicular tumor five years earlier. Cases treated at 200 kv are also included. The records cover extensive examinations of 96 living patients, 72 autopsy reports, and case records and correspondence in the remaining cases. The irradiated areas covered the lower third of the stomach, portions of the small bowel, and a portion of the transverse colon, and the effects on these structures are described separately with correlation of dosage and onset of symptoms.

Effects on the stomach included subjective dyspeptic complaints, antral changes consistent with radiation gastritis, ulcers, and ulcers with perforation. The more serious changes were noted in the higher dosage ranges of 4,500 to 6,000 r to the stomach. Symptoms occurred on the average in two to three months after therapy, perforation and hemorrhage within six months.

Small bowel changes demonstrable roentgenologically included segmentation, thickening of the mucosal pattern, and areas of constriction. The majority of the patients showing such changes had received 4,500 r or more to the bowel. Perforation or obstruction due to fibrosis occurred in 20 cases, and only 3 of these patients survived five years. There was a prolonged period from completion of therapy to onset of symptoms and when symptoms did occur, the patient usually had an acute episode of obstruction or perforation.

Colon changes usually occurred in the transverse section and varied from asymptomatic narrowing to partial obstruction in 20 cases and perforation in 3 cases. The majority of these effects were noted following doses of 5,000 or 6,000 r and over. As in small bowel injury, their appearance was relatively late.

In 9 cases coming to autopsy, a marked effect on the liver was observed. Necrosis occurred in the majority; 3 had fibrosis, and all had terminal jaundice. Over 5,000 r had been given to the liver in most of these cases.

The author summarizes his findings, in part, as follows:

Although all parts of the gastrointestinal tract were affected, the sensitivity varied markedly in the individual patient and, further, there was variation from individual to individual in the effects produced by the same dosage.

The safe tolerance dose would appear to be 4,000 r to the antrum of the stomach, 4,000 to 4,500 r to the small bowel, and 4,500 r to the colon. Liver damage may occur with doses of 5,000 r or more.

No cases of cancer of the gastrointestinal tract were encountered in the study.

Six tables.

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A Study of X-Ray Hazards of Retrograde Urography. William J. Baker, Fred R. Portney, and Raymond Firfer. J. Urol. **74**: 174–175, July 1955.

Measurements were made of the radiation received by the urologists at Cook County Hospital (Chicago) during the course of performance of retrograde pyelography, in 20 cases without protection and in 20 cases with protection in the form of a thin lead apron and a thin lead shield for the hands. For each examination a series of three films was obtained. The dosage to the urologist was determined by an x-ray dosimeter and checked by a dental film plate.

At the end of 20 studies without protection, the total readings were 1,200 mr on the abdominal badge and 3,200 mr on the hand badge. With the use of protection, the exposure was found to be reduced to such minute levels that further observations were discontinued. The use of increased penetration for obese patients produced no appreciable difference in degree of exposure from scattered radiation.

The average exposure to the unprotected urologist from scattered x-rays in obtaining three films was 60 mr, which is slightly above the maximum permissible total-body exposure per day.

[This short article, while it sounds a needed warning to urologists, contains no information of value to radiologists. Data are very inadequately detailed, *e.g.*, "the protection consisted of a thin lead apron and a thin lead shield for the hands." "The x-ray equipment was the standard type which is employed for pyelographic studies." "The doctor was in close proximity to the indwelling ureteral catheters." "The exposure was found to be so minute that . . ." Almost no definite measurements are given, and among those that are, there is a discrepancy in the figure quoted for the dosage of exposure to the hands in the text and in the table. The authors speak mysteriously of "radiation fatigue." —A. S. T.]

One table.

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The Mode of Action of Thorium X on Human Skin. Victor H. Witten and Marion B. Sulzberger. Am. J. Roentgenol. **74:** 90–97, July 1955.

The authors introduce a statement of their own views on the effect of thorium X applied to the skin, by an account of the observations of others. These have shown that biologic effects are due to alpha rays but that the effects extend far beyond the range of these rays in tissue. It has been suggested by earlier work by the senior author and his collaborators that the thorium atoms which have been identified in hair follicles and sweat glands reach these structures by way of the alcohol which is used as a vehicle for the cutaneous application.

With this background, the authors consider three possible means whereby the radioactive material acting from the surface could produce gross and histopathologic changes in the tissues: (1) secondary effects as a result of the formation of new chemical compounds, etc.; (2) direct effects of ionization of alpha rays; (3) direct effect of beta rays. Three ways are also considered by which thorium X may penetrate the skin to reach the hair follicles and sweat glands, namely (1) diffusion of thoron gas, which, however, does not account for the actual presence of thorium X in these tissues; (2) penetration of the vehicle in which the thorium is incorporated, as mentioned above; (3) penetration by radioactive atoms carried by sweat and sebaceous materials. The penetration by one or more of these possible routes is held to be responsible, at least in great part, for the biologic effects of thorium X applied to the surface of the skin, and it is further suggested that, if the ionization effect of the small amounts of alpha activity found in a single hair follicle or sweat duct is insufficient to produce the total biologic effect in any one area, the changes may be the result of cross-firing or summation of radiation action in many adjacent areas including the effects of the marked concentration of thorium X found both on the surface of and within the epidermis.

Five radioautographs; 1 table.

WILLIAM SNOW, M.D.
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Experimental Investigations on Absorption of Roentgen Rays in Various Tissues. G. Balz, R. Birkner, and F. Wachsmann. Strahlentherapie **97:** 382–388, July 1955. (In German)

Contrary to previous experimental series, in which macerated or incinerated specimens have been used in the study of radiation absorption, the authors performed their measurements on samples of bone, cartilage, brain' muscle, and fat, taken from fresh human cadavers. The samples, 1–2 cm. thick, were interposed between the x-ray beam (1 cm. diameter, 50 to 220 kv) and a thimble chamber, all enclosed in a metallic tube. The technic consisted in determining the thickness of water necessary to produce equivalent attenuation of the beam.

Softer wave lengths are comparatively more attenuated by bone than the harder component of radiation. Cartilage (unless calcified, when it approaches bone characteristics) absorbs more than water, but not as much as had been assumed on the basis of earlier determinations. Brain and muscle have about the same coefficient as water, while fat (*i.e.*, white bone marrow) is distinctly less (6 to 25 per cent) absorbing than water, particularly for the softer part of the spectrum.

The radiotherapist can expect a stronger reaction in bone when longer wave lengths are used (at 50 kv the "bone dose" may be 6 times the actual amount measured); as the voltage increases, this difference subsides gradually, and at 200 kv the attenuation factor of bone is 1.5 times that of air. A similar selective absorption of the softer component occurs with cartilage, but to a lesser degree; it cannot be noticed at h.v.l. of 2.0 mm. Cu and beyond. The diminished absorption of long wave lengths by fat has no practical importance.

Two photographs; 3 graphs.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

The Weight and Mortality Response of Male and Female Mice in the Lethal X-Ray Dose Range. William H. Chapman. Radiation Res. **2:** 502–511, July 1955.

The characteristic weight responses for sixty- to eighty-day-old male and female mice exposed to lethal doses of total-body x-irradiation are presented graphically. The weight curves reflect the degree of radiation damage and exhibit different characteristics at different dosage range levels (450 to 1,000 r).

Male mice gained proportionately more weight than female mice exposed to doses of 740 r or less, and lost proportionately more weight than females after doses in excess of 740 r.

Male 28-day survivors of dosages in the mid-lethal or high-lethal range showed the greatest weight loss at two weeks after irradiation (13.6 per cent weight loss by 890-r survivors on the twelfth post-irradiation day). Female 28-day survivors of equivalent doses sustained the greatest weight loss on the fourth post-irradiation day (11.2 per cent weight loss by 890-r survivors on the fourth post-irradiation day).

The 28-day mortality of male mice was consistently greater than that of female mice exposed to the same respective doses within the LD 0 to LD 100 mortality range.

Four figures.

Post-Irradiation Time and Dose-Response Studies on the Incorporation of P^{32} into DNA of Mouse Tissues. Lola S. Kelly, J. Dorothy Hirsch, Genevieve Beach, and Anita H. Payne. Radiation Res. **2:** 490–501, July 1955.

The short-term incorporation of P^{32} into DNA of several mouse tissues, including two transplanted tumors, has been measured after 300, 800, and 2,500 r of total-body roentgen irradiation. P^{32} was injected at

varying times from one hour to six days after irradiation. It was found that each tissue has a characteristic dose-dependent pattern of depression and recovery. For most tissues, the incorporation decreases gradually, reaching a minimum value many hours after irradiation. A marked difference in response was found in the two tumors: the lymphosarcoma showed a much greater depression and an earlier recovery than the mammary carcinoma.

It is suggested that the observed inhibition of incorporation of P^{32} into DNA can be explained largely on the basis of a changed cell population and that it is not necessarily due to a biochemical lesion in DNA synthesis in an individual irradiated cell.

Five graphs; 3 tables. AUTHORS' ABSTRACT

The Effect of Growth Hormone on Recovery from Exposure to X-Radiation. John C. Barlow and E. A. Sellers. Radiation Res. **2**: 461–466, July 1955.

Because of conflicting reports on the effectiveness of the growth hormone of the anterior pituitary (GH) injected after x-irradiation, the authors have made another study of this subject.

The percentage survival of rats after total-body irradiation was improved by repeated injections of GH in doses of 0.5 to 3.0 mg. daily. At the highest dose level GH apparently had an adverse effect on survival.

The injection of 0.5 and 1.0 mg. of GH daily exerted a temporary beneficial effect on the weight response of animals irradiated with 500 and 650 r but did not alter the weight response of rats given 800 r. The administration of 3.0 mg. of GH daily did not change the weight response of rats given 650 r.

Irradiation produced a slight but significant *increase* in liver weight relative to body weight, though the reason for this is not immediately apparent. The increase in liver weight was not affected by the administration of GH, nor did the administration of GH affect the relationship in normal non-irradiated rats.

The results of these experiments agree with those of Selye (The Story of the Adaptation Syndrome, Montreal, 1952) in that no beneficial effect on mortality was observed and that GH partially prevented the initial loss of body weight after sublethal irradiation. In the present experiments, however, irradiation alone did not cause a fall in weight of the liver, and GH, in the dosage given, did not modify appreciably the effects usually seen after irradiation in the thymus, spleen, liver, or other organs studied.

Three figures; 1 table.

Influence of X-Ray Irradiation on Glucose Transport in the Rat Intestine. Lawrence E. Detrick, Harvey C. Upham, Dorothy Highby, Virginia Debley, and Thomas J. Haley. Radiation Res. **2**: 483–489, July 1955.

Acute whole-body irradiation causes extensive damage to the small intestine. However, the repair process occurs within the third post-irradiation day. By the use of the Fisher-Parson intestinal perfusion apparatus, it was found that, although non-irradiated intestinal segments were remarkably constant in their transport of glucose across the intestinal membrane, irradiation produced a significant decrease in glucose transport on post-irradiation days three to six. Such changes are indicative of a decrease in permeability of the intestinal wall or an increase in the metabolite utilization. The former factor appears to be of the greatest importance.

It was also observed that dehydration occurred during the first three post-irradiation days followed by hydration, which reached a peak on the sixth post-irradiation day.

Histologic examination indicated that most of the irradiation damage to the intestine occurred on the first post-irradiation day, with the recovery occurring by the third day. Such results serve to point out that histologic recovery from irradiation injury is no guarantee of a physiologically functional tissue.

Four figures. AUTHORS' ABSTRACT

The Comparative Effect of Platelets on Prothrombin Utilization from Dogs in the Degenerative and Regenerative Phase of Irradiation Bone Marrow Aplasia. E. P. Cronkite, G. J. Jacobs, and P. K. Schork. Radiation Res. **2**: 439–446, June 1955.

In the irradiated dog (150 to 600 r), prothrombin utilization was found to be impaired in the degenerative phase of radiation injury and more rapid in the regenerative phase than would be anticipated on the basis of the platelet counts alone. These differences in prothrombin utilization can be correlated with either spontaneous or artificially adjusted platelet counts. In the degenerative stage of marrow aplasia, the platelets are less active than in normal blood, or in the regenerative stage, in accelerating prothrombin utilization in shed blood. The greater activity in the regenerative phase is probably accounted for by the increased size and lability of the newly formed platelets. The lesser activity in the degenerative phase is more probably due to increased levels of plasma lipid antithromboplastins than to changes in the platelet *per se*.

Severity of bleeding is best correlated with the duration of thrombopenia when platelet levels fall below certain critical levels rather than the actual platelet level.

Five graphs.

Effects of 50 Roentgens and 25 Roentgens Fractional Daily Total-Body γ-Irradiation in the Burro. John H. Rust, Bernard F. Trum, John J. Lane, U. S. Grant Kuhn, III, John R. Paysinger, and Thomas J. Haley. Radiation Res. **2**: 475–482, July 1955.

A study is reported of the response of the burro (*Equus asinus asinus*) to 50 and 25 r fractional daily total-body cobalt 60 γ-irradiation. The mean survival time for the 50-r/day study was thirty days with a range of twenty-five to thirty-five days, and in the 25-r/day animals it was sixty-three days with a range of forty-seven to eighty-seven days. All hematologic values were decreased. The lymphocyte was the most sensitive cell, and the eosinophil the most resistant. Platelets were reduced significantly with 725 r at 25 r/day. A pronounced hyperferremia was observed after 500 r in the 50-r/day animals and after 200 r in the 25-r/day group. This elevation continued until near death. The clinical syndrome was characterized by weight loss, ulcerations, hyperesthesia, and hemorrhagic diathesis.

The similarities of response of the animals receiving 50 and 25 r/day with those receiving 100 to 400 r/day are discussed.

One graph; 5 tables.

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